THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[THIRD SERIES.]

ART. XLVII.—*Research on the Absolute Unit of Electrical Resistance;* by HENRY A. ROWLAND, Professor of Physics in the Johns Hopkins University, Baltimore, Md.

[Continued from page 291.]

Theory of the Method.

WHEN a current is induced in a circuit by magnetic action of any kind, Faraday has shown that the induced current is proportional to the number of lines of force cut by the circuit and inversely as the resistance of the circuit. If we have two circuits near each other, the first of which carries a current, and the second is then removed to an infinite distance, there will be a current in it proportional to the number of lines of force cut. Let now a unit current be sent through the second circuit and one of strength E through the first; then, on removing the second circuit, work will be performed which we easily see is also proportional to the number of lines of force cut. Hence, if EM is the work done, Q is the induced current, and R is the resistance of the second circuit,

$$Q = CE\frac{M}{R},$$

where C is a constant whose value is unity on the absolute system.

When the current in the first circuit is broken, the lines of force contract on themselves, and the induced current is the same as if the second circuit had been removed to an infinite distance. If the current is reversed the induced current is twice as great; hence in this case

$$Q = 2E\frac{M}{R} \text{ or } R = 2M\frac{E}{Q}.$$

Hence, to measure the absolute resistance of a circuit on this method, we must calculate M and measure the ratio of Q to E. M is known as the mutual potential of the two circuits with unit currents, and mathematical methods are known for its calculation.

The simplest and best form in which the wire can be wound for the calculation of M is in parallel circular coils of equal size and of as small sectional area as possible. For measuring E a tangent galvanometer is needed, and we shall then have

$$E=\frac{H}{G}\tan\theta,$$

where H is the horizontal intensity of the earth's magnetism at the place of the tangent galvanometer, and G the constant of the galvanometer.

For measuring Q we must use the ballistic method, and we have

$$Q=\frac{H'}{G'}\frac{T}{\sqrt{\pi^2+\lambda^2}}E^{\frac{\lambda}{\pi}\tan^{-1}\frac{\pi}{\lambda}}2\sin\tfrac{1}{2}\theta',$$

which for very small values of λ becomes

$$Q=\frac{H'}{G'}\frac{T}{\pi}2\sin\tfrac{1}{2}\theta'(1+\tfrac{1}{2}\lambda-\tfrac{1}{6}\lambda^2)$$

$$\therefore R=M\frac{H}{H'}\frac{G'}{G}\frac{\pi\tan\theta}{T\sin\frac{1}{2}\theta'}\frac{1}{1+\frac{1}{2}\lambda-\frac{1}{6}\lambda^2},$$

where H′ is the horizontal component of the earth's magnetism at the place of the small galvanometer, G′ its constant, T the time of vibration of the needle, and λ the logarithmic decrement.

The ratio of H′ to H can be determined by allowing a needle to vibrate in the two positions. But this introduces error, and by the following method we can eliminate both this and the distance of the mirror from the scale by which we find θ' and the error of tangent galvanometer due to length of needle. The method merely consists in placing a circle around the small galvanometer and then taking simultaneous readings with the current passing through it and the tangent galvanometer, before and after each experiment. Let α and α' be the deflections of the tangent galvanometer and the other galvanometer respectively, and let G″ be the constant of the circle at the point where the needle hangs, then

$$\frac{H}{G}\tan\alpha=\frac{H'}{G''}\tan\alpha',$$

and we have finally

$$R=M\frac{\pi}{T}\frac{G}{G''}\frac{\tan\alpha'}{\tan\alpha}\frac{\tan\theta}{\sin\frac{1}{2}\theta'}\frac{1}{1+\frac{1}{2}\lambda-\frac{1}{6}\lambda^2},$$

which does not contain H or H′, and the distance of the mirror from the scale does not enter except as a correction in the ratio of sin $\frac{1}{2}\theta'$ and tan α'; and, as α and θ can be made nearly equal, the correction of the tangent galvanometer for the length of needle is almost eliminated. When the method of recoil is used, we must substitute $\dfrac{1}{1+\frac{1}{2}\left(\frac{\lambda}{\pi}\right)^2}$ for the term involving λ, and sin $\frac{1}{2}$A′+sin $\frac{1}{2}$B′ in the place of sin $\frac{1}{2}\theta'$, A′ and B′ being the greater and smaller arcs in that method. This is on the supposition that λ is small.

The ratio of G″ to G must be so large, say 12,000, that it is difficult to determine it by direct experiment, but it is found readily by measurement or indirect comparison.

It is seen that in this equation the quantities only enter as the first powers, and that the only constants to be determined which enter the equation are M, G and G″, which all vary in simple proportion to the linear measurement. It is to be noted also that the only quantities which require to be reduced to standard measure are M and T, and that the others may all be made on any arbitrary scale. No correction is needed for temperature except to M. Indeed, I believe that this method exceeds all others in simplicity and probable accuracy and its freedom from constant errors, seeing that every quantity was varied except G″ and G, whose ratio was determined within probably one in three thousand by two methods.

Having obtained the resistance of the circuit by this method, we have next to measure it in ohms. For this purpose the resistance of the circuit was always adjusted until it was equal to a certain German silver standard, which was afterward carefully compared with the ohm. This standard was about thirty-five ohms.

By this method, the following data are needed.

1. Ratio of constants of galvanometer and circle.
2. Ratio of the tangents of the two deflections of tangent galvanometer.
3. Ratio of the deflection to the swing of the other galvanometer.
4. Mutual potential of induction coils on each other.
5. Time of vibration of the needle.
6. Resistance of standard in ohms.

For correction we need the following:

1. The logarithmic decrement.
2. Distance of mirror from scale.
3. Coefficient of torsion of suspending fiber.
4. Rate of chronometer.
5. Correction to reduce to standard meter.

6. Variation of the resistance of German silver with the temperature.
7. Temperature of standard resistance.
8. Arc of swing when the time of vibration is determined.
9. Length of needle in tangent and other galvanometer (nearly compensated by the method).
10. The variation of resistance of circuit during the experiment.

The following errors are compensated by the method of experiment.

1. The local and daily variation of the earth's magnetism.
2. The variation of the magnetism of the needle.
3. The magnetic and inductive action of the parts of the apparatus on each other.
4. The correction for length of needle in the tangent galvanometer (nearly).
5. The axial displacement of the wires in the coils for induction.
6. The error due to not having the coils of the galvanometer and the circle parallel to the needle.
7. Scale error (partly).
8. The zero error of galvanometers.

Calculation of Constants.

Circle.—For obtaining the ratio of G to G″, it is best to calculate them separately and then take their ratio, though it might be found by Maxwell's method ("Electricity," Article 753). But as the ratio is great, the heating of the resistances would produce error in this latter method.

For the simple circle,

$$G''=2\pi\frac{A^2}{(A^2+B^2)^{\frac{3}{2}}}=\frac{2\pi}{A}\left(1-\frac{3}{2}\left(\frac{B}{A}\right)^2+\ \&c.\right)$$

where A is its radius and B the distance of the plane of the circle to the needle on its axis.

Galvanometer for Induction Current.—For the more sensitive galvanometer, we must first assume some form which will produce a nearly uniform field in its interior, without impairing its sensitiveness. If we make the galvanometer of two circular coils of rectangular section whose depth is to its width as 108 to 100, and whose centers of sections are at a radius apart from each other, we shall have Maxwell's modification of Helmholtz's arrangement. The constant can then be found by calculation or comparison with another coil.

Maxwell's formulæ are only adapted to coils of small section. Hence we must investigate a new formula.*

* A formula involving the first two terms of my series, but applying only to the special case of a needle in the center of a single circle of rectangular section, is given by Weber in his "Elektrodynamische Maasbestimmungen inbesondere Widerstandsmessungen," S. 372.

Let N be the total number of windings in the galvanometer.
Let R and r be the outer and inner radii of the coils.
Let X and x be the distances of the planes of the edges of the coils from the center.
Let α be the angle subtended by the radius of any winding at the center.
Let b be the length of the radius vector drawn from the center to the point where we measure the force.
Let θ be the angle between this line and the axis.
Let c be the distance from the center to any winding.
Let w be the potential of the coil at the given point.

Then (Maxwell's "Electricity," Art. 695), for one winding,

$$w=-2\pi\left\{1-\cos\alpha+\sin^2\alpha\left(\frac{b}{c}Q_1'(\alpha)Q_1(\theta)+\frac{1}{2}\left(\frac{b}{c}\right)^2 Q_2'(\alpha)Q_2(\theta)+\&c.\right)\right\}$$

and for two coils symmetrically placed on each side of the origin,

$$w=4\pi\left\{\cos\alpha-\sin^2\alpha\left(\frac{1}{2}\left(\frac{b}{c}\right)^2 Q_2'(\alpha)Q_2(\theta)+\frac{1}{4}\left(\frac{b}{c}\right)^4 Q_4'(\alpha)Q_4(\theta)+\&c.\right)\right\}$$

where $Q_2(\theta)$, $Q_4(\theta)$, &c., denote zonal spherical harmonics, and $Q_2'(\alpha)$, $Q_4'(\alpha)$, &c., denote the differential coefficients of spherical harmonics with respect to $\cos\alpha$.

As the needle never makes a large angle with the plane of the coils, it will be sufficient to compute only the axial component of the force, which we shall call F. Let us make the first computation without substitution of the limits of integration, and then afterward substitute these:

$$F=\frac{1}{2}\frac{N}{(R-r)(X-x)}\iint\frac{dw}{dx}dxdr$$

$$F=\frac{1}{2}\frac{N}{(R-r)(X-x)}\int wdr,$$

and we can write

$$F=\frac{2\pi N}{(R-r)(X-x)}\left\{H_0+H_2b^2Q_2(\theta)+H_4b^4Q_4+\ \&c.\right\}$$

where $H_0=x\log_\epsilon(r+\sqrt{x^2+r^2})$

$$H_i=-\frac{1.3.5\ldots(2i-1)}{i(1.2.3\ldots i)}\frac{\sin^3\alpha}{x^{i-1}}\left\{A_i\frac{\cos^{2i-4}\alpha}{2i-1}+B_i\frac{\cos^{2i-6}}{2i-3}+\ \&c.\right\}$$

$$A_i=i$$

$$B_i=A_i\frac{2i-4}{2i-1}-\frac{i(i-1)(i-2)}{(2i-1)2}$$

$$C_i=B_i\frac{2i-6}{2i-3}+\frac{i(i-1)(i-2)\ldots(i-4)}{(2i-1)(2i-3)2.4}$$

$$D_i=C_i\frac{2i-8}{2i-5}-\frac{i(i-i)\ldots(i-6)}{(2i-i)(2i-3)(2i-5)2.4.6}$$

$$E_i=\&c.,\&c.$$

Substituting the limits for x, r and α, we find

$$H_0 = X \log_\varepsilon \frac{R+\sqrt{X^2+R^2}}{r+\sqrt{X^2+r^2}} - x \log_\varepsilon \frac{R+\sqrt{x^2+R^2}}{r+\sqrt{x^2+r^2}}$$

$$H_2 = -\tfrac{1}{2}\left\{ \frac{1}{X}\left(\frac{R^3}{(R^2+X^2)^{\frac{3}{2}}} - \frac{r^3}{(r^2+X^2)^{\frac{3}{2}}}\right) - \frac{1}{x}\left(\frac{R^3}{(R^2+x^2)^{\frac{3}{2}}} - \frac{r^3}{(r^2+x^2)^{\frac{3}{2}}}\right)\right\}$$

$$H_4 = -\frac{1}{24}\left\{ \frac{R^3}{X^3(X^2+R^2)^{\frac{3}{2}}}(20X^4+7X^2R^2+2R^4) - \right.$$

$$\frac{r^3}{X^3(X^2+r^2)^{\frac{3}{2}}}(20X^4+7X^2r^2+2r^4) - \frac{R^3}{x^3(x^2+R^2)^{\frac{3}{2}}}(20x^4+7x^2R^2+2R^4)$$

$$\left. + \frac{r^3}{x^3(x^2+r^2)^{\frac{3}{2}}}(20x^4+7x^2r^2+2r^4)\right\}$$

The needle consisted of two parallel lamina of steel of length, l, and a distance, W, from each other. As the correction for length is small, we may assume that the magnetism of each lamina is concentrated in two points at a distance $n\,l$ from each other, where n is a quantity to be determined.
Hence

$$G = \frac{2\pi N}{(R-r)(X-x)}\left\{ H_0 + H_2 \frac{l^2 n^2}{4} Q_2(\theta') + H_4 \frac{l^4 n^4}{16} Q_4(\theta') + \text{etc.}\right\}$$

where $\cos\theta' = \dfrac{W}{\sqrt{(\frac{1}{2}nl)^2+W^2}}$, seeing that the needle hangs parallel to the coils. In short thick magnets, the polar distance is about $\frac{2}{3}\,l$ and the value of n will be about $\frac{2}{3}$. For all other magnets it will be between this and unity. In the present case $n=\frac{3}{4}$ nearly.

As all the terms after the first are very minute, this approximation is sufficient, and will at least give us an idea of the amount of this source of error.

Induction Coils.

The induction coils were in the shape of two parallel coils of nearly equal size and of nearly square section.

Let A and a be the mean radii of the coils. Let b be the mean distance apart of the coils.

Let

$$c = \frac{2\sqrt{Aa}}{\sqrt{(A+a)^2+b^2}}.$$

Supposing the coils concentrated at their center of section we know that

$$M_0 = 4\pi\sqrt{Aa}\left\{\left(\frac{2}{c}-c\right)F(c) - \frac{2}{c}E(c)\right\}$$

where F(c) and E(c) are elliptic integrals.

If ζ and η are the depth and width of each coil, the total value of M will be, when $A=a$ nearly,

$$M=M_0+\frac{1}{12}\left\{\frac{d^2M_0}{dA^2}\eta^2+\frac{d^2M_0}{db^2}\zeta^2\right\}+\text{etc.}$$

and we find

$$\frac{d^2M_0}{dA^2}=-\frac{\pi}{A}\left\{\frac{E(c)}{2A(1-c^2)}\left(2Ac+\frac{4b^2c^3}{8A(1-c^2)}(1-3c^2+2c^4)\right)-F(c)\left(c+\frac{b^2c^3}{4A^2}\right)\right\}$$

$$\frac{d^2M_0}{db^2}=\frac{\pi c}{A(1-c^2)}\left\{F(c)\left(2(1-c^2)-\frac{b^2c^2}{4A^2}(2-c^2)\right)-E(c)\left(2-c^2-b^2c^2\frac{1-c^2+c^4}{2A^2(1-c^2)}\right)\right\}$$

Corrections.

Calling β and δ the scale deflections corresponding to tan α' and sin $\frac{1}{2}\theta'$, we may write our equation for the value of the resistance

$$R'=\frac{K}{T}\frac{\tan\theta}{\tan\alpha}\frac{\beta}{\delta}\frac{1-\frac{1}{4}\left(\frac{\beta}{D}\right)^2+\frac{1}{8}\left(\frac{\beta}{D}\right)^4}{1-\cdot35\left(\frac{\delta}{D}\right)^2+\cdot22\left(\frac{\delta}{D}\right)^4}(1+A+\text{ etc.})$$

where R′ is the resistance of the circuit at a given temperature 17·0° C., and $K=2\pi M\frac{G}{G''}(1+a+b+\text{etc.})$, in which A, B, etc. and a, b, etc. are the variable and constant corrections respectively.

a. Correction for damping,

$$a=-\tfrac{1}{2}\lambda+\tfrac{5}{12}\lambda^2.$$

b. Torsion of fiber.

The needle of the tangent galvanometer was sustained on a point and so required no correction. The correction for the torsion in the other galvanometer is the same for β and δ and hence only affects T. Therefore, if t is the coefficient of torsion,

$$b=-\tfrac{1}{2}t.$$

c. Rate of chronometer.

Let p be the number of seconds gained in a day above the normal time

$$c=-\frac{p}{86400}.$$

d. Reduction to normal meter. The portion of this reduction which depends on temperature must be treated under the variable corrections. Let m be the excess of the meter used above the normal meter, expressed in meters; then

$$d=+m.$$

e. Correction of T for the arc of vibration. This arc was always the same, starting at c_1 and being reduced by damping to about c_n,

$$e = +\frac{1}{128n\lambda}(c_1{}^2 - c_n{}^2),$$

where c_1 and c_n are the total arcs of oscillation.

f. Correction for length of needles. For the tangent galvanometer, the correction is variable. For the circle it is

$$f = +\tfrac{3}{4}\left(\frac{l}{A}\right)^2$$

where l is half the distance between the poles of the needle and A the radius of circle. For the other galvanometer it is included in the formula for G.

A. Reduction to normal meter. As the dimension of R is a velocity and the induction coils were wound on brass, the correction is

$$A = +\gamma(t' - t'')$$

where γ is the coefficient of expansion of brass or copper, t' the actual and t'' the normal temperature.

B. Correction of standard resistance for temperature. Let μ be the variation of the resistance for 1° C., t''' be the actual and t^{iv} the normal temperature 17·°0 C.; then

$$B = -\mu(t''' - t^{iv}).$$

C. Correction for length of needle in tangent galvanometer,

$$C = +\frac{15}{4}\sin(\alpha + \alpha')\left(\frac{l'}{A'}\right)^2(\alpha' - \alpha)$$

where l' is half the distance between the poles of the needle and A′ is the radius of the coil.

D. The resistance of the circuit was constantly adjusted to the standard, but during the time of the experiment the change of temperature of the room altered the resistance slightly; this change was measured and the correction will be plus or minus one-half this. The resistance was adjusted several times during each experiment. The correction is $\pm$D.

Some of the errors which are compensated by the experiment need no remark and I need speak only of the following.

No. 3. By the introduction of commutators at various points all mutual disturbance of instruments could be compensated.

No. 5. In winding wire in a groove, it may be one side or the other of the center. By winding the coils on the center of cylinders which set end to end, on reversing them and taking the mean result, this error is avoided.

No. 6. The circle was always adjusted parallel to the coils of the galvanometer. Should they not be parallel to the needle, G and G″ will be altered in exactly the same ratios and will thus not affect the result. The same may be said of the deflection of the magnet from the magnetic meridian due to torsion.

No. 7. β and δ both ranged over the same portion of the scale and so scale error is partly compensated.

No. 8. The zero-point of all galvanometers was eliminated by equal deflections on opposite sides of the zero-point.

Instruments.

Wire and coils.—The wire used in all instruments was quite small silk-covered copper wire, and was always wound in accurately turned* brass grooves in which a single layer of wire just fitted. The separate layers always had the same number of windings, and the wire was wound so carefully that the coils preserved their proper shape throughout. No paper was used between the layers. As the wire was small, very little distortion was produced at the point where one layer had to rise over the tops of the wires below. Corrections were made for the thickness of the steel tape used to measure the circumference of each layer; also for the sinking of each layer into the spaces between the wires below, seeing that the tape measures the circumference of the tops of the wires. The steel tape was then compared with the standard.

The advantages of small wire over large are many; we know exactly where the current passes; it adapts itself readily to the groove without kinks; it fills up the grooves more uniformly; the connecting wires have less proportional magnetic effect; and lastly, we can get the dimensions more exactly. The size of wire adopted was about No. 22 for most of the instruments.

The mean radius having been computed, the exterior and interior radii are found by addition and subtraction of half the depth of the coil. The sides of the coil were taken as those of the brass groove.

All coils were wound by myself personally to insure uniformity and exactness.

Tangent galvanometer.—This was entirely of brass or bronze, and had a circle about 50 cm. diameter. The needle was 2·7 cm. long and its position was read on a circle 20· cm. diameter, graduated to 15′. The graduated circle was raised so that the aluminium pointer was on a level with it, thus avoiding parallax. The needle and pointer only weighed a gram or two, and rested on a point at the center which was so nicely made that it would make several oscillations within 1° and would come to rest within 1′ or 2′ of the same point every time. I much prefer a point with a *light* needle carefully made to any suspended needle for the tangent galvanometer, especially as a raised circle can then alone be used. The needle

* To obtain an accurate coil an accurate groove is necessary, seeing that otherwise the wire will be heaped up in certain places. The circle of the tangent galvanometer, which was made to order in Germany, had to be re-turned in this country before use, and much time was lost before finding out the source of the difficulty.

was suspended at a distance from any brass which might have been magnetic. There were a series of coils ascending nearly as the numbers 1, 3, 9, 27, 81, 243, whose constants were all known, but only one was used in this experiment. The probable error of a single reading was about $\pm 1'$.

Galvanometer for induction current.—This was a galvanometer on a new plan, especially adapted for the absolute measurement of weak currents. It was entirely of brass, except the wooden base, and was large and heavy, weighing twenty or twenty-five pounds. It could be used with a mirror and scale or as a sine galvanometer. It will be necessary to describe here only those portions which affect the accuracy of the present experiment.

The coils were of the form described above in the theoretical portion, and were wound on a brass cylinder about 8·2 cm. long and 11·6 cm. diameter in two deep grooves about 3· cm. deep and 2·5 cm. wide. The opening in the center for the needle was about 5·5 cm. diameter and the cylinder was split by a saw-cut so as to diminish the damping effect. This coil was mounted on a brass column rising from a graduated circle by which the azimuth of the coil could be determined by two verniers reading to 30″. Through the opening in the coil beneath the needle passed a brass bar 95 cm. long and 2 cm. broad, carrying a small telescope at one end. In the present experiment, this bar was merely used in the comparison of the constant of the instrument with that of another instrument. For this purpose the instrument is used as a sine galvanometer by which a great range can be secured, and it could be compared with a coil having a constant twenty-three times less and which was used with telescope and scale.

The coils contained about five pounds of No. 22 silk-covered copper wire in 1790· turns.

Two needles were used in this galvanometer, each constructed so that its magnetic axis should be invariable; this was accomplished by affixing two thin laminæ of glass-hard steel, to the two sides of a square piece of wood, with their planes vertical. This made a sort of compound magnet very strong for its length, and with a constant magnetic axis. The first needle had a nearly rectangular mirror 2·4 by 1·8 cm. on the sides and ·22 cm. thick. The other needle had a circular mirror 2·05 cm. diameter and about 1 mm. thick. The needle of the first was 1·27 cm. and of the second 1·20 cm. long, and the pieces of wood were about ·45 cm. and ·6 cm. square respectively. The moment of inertia of both was much increased by two small brass weights attached to wires in extension of the magnetic axis, thus extending the needles to a length of 4·9 cm. and 4·2 cm. respectively. The total weights were 5·1 and 5·6 grams and the times of vibration about 7·8 and 11·5 seconds. They were suspended by three single fibers of silk about 43 cm. long.

In front of the needle was a piece of plane-parallel glass. This and the mirrors were made by Steinheil of Munich, and were most perfect in every way.

In the winding of the coils every care was taken, seeing that a small error in so small a coil would produce great relative error. And for this reason the constant was also found by comparison with another coil. The following were the dimensions:

$$\text{Mean radius } 4{\cdot}3212 \text{ c. m.}$$
$$R=5{\cdot}6212 \qquad r=3{\cdot}0212$$
$$X=3{\cdot}475565 \qquad x=\ {\cdot}935565$$
$$R-r=2{\cdot}6000 \qquad X-x=2{\cdot}54000$$
$$N=1790{\cdot}$$

whence

$$F=1832{\cdot}25-1{\cdot}70\ b^2Q_2(\theta)-4{\cdot}50\ b^4Q_4(\theta)+{\cdot}90\ b^6Q_6(\theta)-\&c.$$

Taking the mean dimensions of the two needles, we have

$$l=1{\cdot}23, \quad w={\cdot}52, \quad n=\tfrac{3}{4}, \quad \cos\theta'={\cdot}748.$$
$$Q_2(\theta')=+{\cdot}339, \quad Q_4(\theta')=-{\cdot}354, \quad Q_6(\theta')=-{\cdot}275.$$
$$\therefore G=1832{\cdot}25-{\cdot}083+{\cdot}071-{\cdot}002+\&c.=1832{\cdot}24.$$

The coil with which this galvanometer was compared was the large coil of an electro-dynamometer similar to that described in Maxwell's "Electricity," Art. 725, but smaller. The coil was on Helmholtz's principle with a diameter of 27·5 cm., and was very accurately wound on the brass cylinder. There was a total of 240 windings in the coil. The constant of this coil was 78·371 by calculation.

To eliminate the difference of intensity of the earth's magnetism, an observation was first made and then the positions of the instruments were changed so that each occupied exactly the position of the other: the square root of the product of the two results was the true result free from error.

The coils of the galvanometer could be separated so that an outer and inner pair could be used together. By comparing these parts separately and adding the constants together we find G. Hence two comparisons are possible, one with the coils together and the other with them separate. The results were for the ratio of the constants

$$23{\cdot}3931 \quad \text{and} \quad 23{\cdot}4008,$$

which give

$$G=1833{\cdot}37 \quad \text{and} \quad 1833{\cdot}98.$$

The mean result is

$$1833{\cdot}67 \pm {\cdot}09,$$

and this includes seven determinations with two reversals of instruments. This result is one part in thirteen hundred greater than found by direct calculation, which is to be accounted for by the small size of the galvanometer coils and the consequent difficulty of their accurate measurement. As comparison with the electro-dynamometer has such a small probable error, and as it is a much larger coil, it seems best to give this number twice the weight of that found by calculation: we thus obtain

$$G = 1833{\cdot}19$$

as the final result.

It does not seem probable that this can be in error more than one part in two or three thousand.

Telescope, scale, &c.—The telescope, mirrors and plane-parallel glass were all from Steinheil in Munich, and left nothing to be desired in this direction, the image of the scale being so perfect that fine scratches on it could be distinguished. The telescope had an aperture of 4 cm. and a magnifying power of 20 was used. The scale was of silvered brass, one meter long and graduated to millimeters.

Induction coils.—A coil was wound in a groove in the center of each of three accurately turned brass cylinders of different lengths. Two of them only were used at a time, by placing them end to end, the ends being ground so that they laid on each other nicely. The two coils could be placed in four positions with respect to each other, in each of which they were very exactly the same distance apart. This distance for each of the four positions, was determined at three parts of the circumference by means of a cathetometer, with microscopic objective, reading to $\frac{1}{50}$ mm. The mean of all twelve determinations was the mean distance. In using the coils they were always used in all four positions. The probable error of each set of twelve readings was $\pm{\cdot}001$ mm. The data are as follows, naming the coils A, B and C:

Mean radius of $A=13{\cdot}710$, of $B=13{\cdot}690$, of $C=13{\cdot}720$.

Mean distance apart of A and $B=6{\cdot}534$, of A and $C=9{\cdot}574$, of B and $C=11{\cdot}471$.

$N=154$ for each coil, $\xi={\cdot}90$, $\eta={\cdot}84$.

For A and B we have

$$M=3774860{\cdot}+\tfrac{1}{12}(74250{\cdot}-66510{\cdot})=3775500{\cdot}$$

The remaining terms of the series are practically zero, as was found by dividing one of the coils into parts and calculating the parts separately and adding them.

For A and C

$$M=2561410{\cdot}+\tfrac{1}{12}(34000{\cdot}-27230{\cdot})=2561974{\cdot}$$

For B and C

$$M=2050600{\cdot}+\tfrac{1}{12}(27500{\cdot}-19800{\cdot})=2051320{\cdot}$$

The calculation of the elliptic integrals was made by aid of the tables of the Jacobi function, q, given in Bertrand's "Traité de Calcul Integrale" as well as by the expansions in terms of the modulus after transforming them by the Landen substitution.

[To be continued.]

ART. XLVIII.—*On a fourth mass of Meteoric Iron from Augusta County, Virginia;* by J. W. MALLET.

IN 1871 I described* three masses of meteoric iron found a few miles from Staunton in this State; still another has lately been brought to light under the following circumstances. About the year 1858 or 1859 a negro man, named Alf, belonging to Mr. Robert Van Lear (on whose land the largest of the three already described meteorites was found), brought to Staunton a lump of iron which he had found, and tried to sell it, but no one considered it curious or valuable enough to pay the price asked, a dollar. This man is dead, and it cannot now be ascertained where he found the specimen, but probably on Mr. Van Lear's land, and undoubtedly in his immediate neighborhood. Failing to sell the mass, Alf threw it away in a vacant plot of ground behind a blacksmith's shop. Here it lay for several years, until it was used, with some other loose material, to build a stone fence. On account of its irregular shape and great weight it soon fell out of the fence, and was then thrown aside in the rear of a dentist's house. He used it for some time as an anvil on which to hammer metals and crack nuts, and afterwards had it built into a wall round the curbing of a cistern. Here, during the summer of 1877, it came under the notice of Mr. M. A. Miller of Staunton,† who obtained possession of it, had it removed from the wall, and near the end of the year disposed of it to Messrs. Ward and Howell of Rochester, N. Y. These gentlemen, who were at the time engaged in the arrangement of a geological and zoological collection which they had contracted to furnish for the University of Virginia, allowed me to examine the meteorite before it was sent to Rochester, and have furnished me with material for its analysis. They are having the largest part of the iron cut into slices as specimens for sale.

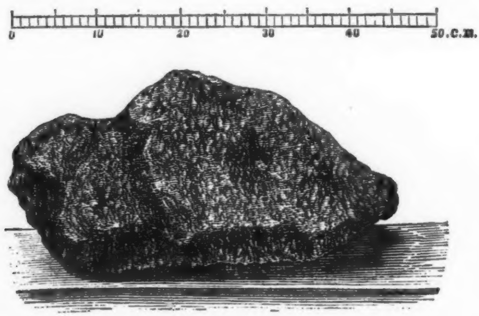
The shape of the mass is like that of many other metallic meteorites, irregularly rounded, larger at one end than the other, something like a shoulder of mutton in general outline, with well marked concave depressions or pittings. The woodcut on this page is from a photograph of the specimen.

The greatest length was 45·7 centimeters, greatest width 29·2 centimeters, and greatest thickness 20·3 centimeters. The weight was 152 pounds, or 68.950 grams. The crust was not as thick as that upon the masses from the same locality previously examined, and at a number of points the metallic luster

* This Journal, III, ii, 10.

* The above account of the history of the meteorite was furnished by Mr. Miller.

of the iron was visible. Magnetic polarity was detectable at various parts of the surface. The specific gravity, taken with a clean piece of 87·5 grams was found = 7·688 at 18° C. The iron is compact and crystalline, with plates of Schreibersite running through it, while a few specks of troilite were detected. On etching with nitric acid the Widmanstättian figures are clearly and beautifully brought out, and their general character is quite the same with that shown upon the etched surfaces of the three previously described masses. On one surface two distinct sets of crystalline markings are observable, the angles of intersection in each of these being nearly uniform.



An analysis made by Mr. J. R. Santos of Guayaquil, Ecuador, now working in this laboratory, gave the following results.

Iron	91·439	Sulphur	·018
Nickel	7·559	Chlorine	*trace*
Cobalt	·608	Carbon	.142
Copper	·021	Silicon (counted as silica)	·108
Tin	*trace*		
Phosphorus	·068		99·963

The chlorine occurs as ferrous chloride, soluble in water. 87·5 grams of iron was used for the analysis, so as to render accurate the determination of the minor constituents. A partial examination of another specimen, however, showed that, as usual in such masses, the distribution of the Schreibersite, and probably of the nickel in the alloy, is not altogether uniform. The average amount of nickel is somewhat less than in the three formerly described masses, and the proportion of cobalt and copper rather larger; but there can be no doubt, I think, that all four specimens, found in the same neighborhood, resembling each other closely in all their physical properties, and exhibiting the same general chemical character, represent different portions of the same meteoric fall.

University of Virginia, March 6, 1878.

ART. XLIX.—*On the Relative Positions of the Forest Bed and associated Drift Formations in Northeastern Iowa*; by W. J. McGEE.

THE term "Forest Bed" was applied by Dr. J. S. Newberry to a "layer of carbonaceous matter, with logs and stumps, and sometimes upright trees,"* observed by him in Ohio during the progress of the geological survey of that State. The same formation has been observed at many points in Illinois, all through southwestern Indiana, at many localities in Wisconsin, throughout northeastern Iowa, in Canada, and in many other places. Wherever found it rests upon true glacial Drift, and within it are found remains of the mammoth, the mastodon, of *Castoroides ohioensis*, *Bison latifrons*, and their contemporaries. In most of the localities just mentioned the Forest Bed is overlaid by a partially stratified deposit, regarding the origin and age of which there is some doubt. The condition of the superficial deposits in the neighborhood of the residence of the writer is such as to throw much light on the question of the true geological position of this formation. A few sections are appended.

I. *A well in Farley, Iowa.*

1. Surface soil	2 feet.
2. Clean clay with occasional granite bowlders	15 "
3. Clay with bowlders, gravel and flint	12 "
4. Thin-bedded, black, carbonaceous, shaly clay, with fragments of wood	10 "
5. Thick-bedded do., with much-decomposed fragments of wood. Undisturbed by glacier	4 "
6. Hard yellow clay, sometimes with bowlders	1 "
7. Do. with gravel and small bowlders	2 "
8. Niagara limestone.	

Some of the wood found in this well—probably Willow (*Salix* ——) though not certainly determined—was so well preserved as to be combustible. No. 4 displayed evidence of alluvial action. Fragments of endogenous plants were found in the lower part of this stratum.

II. *A well* 250 *feet from* I.

1. Surface soil	3 feet.
2. Clay with occasional granite bowlders	10 "
3. Clay with bowlders, gravel and flint (broken hornstone), and some sand	8 "
4. Same as No. 4 in last, but more carbonaceous	7 "
5. Same as in I	3 "
6., 7. } Yellow clay with sand, gravel and small bowlders	4 "
8. Niagara limestone.	

* Ohio Geol. Rep., 1874, pt. I, vol. ii, p. 3.

Pieces of the soft shaly substance from the lower part of No. 4 were found to be slowly combustible, but contained too much earthy matter to burn readily. Charred wood and sticks burned off at one end were found in this well.

III. *A well two miles northwest from last.*

Stratification not personally observed. At about twenty feet a large stump of a tree identified as Red Cedar (*Juniperus virginiana*) was struck in one side of the well. Below it a stratum of the older glacial Drift several feet in thickness was penetrated. The stump retained so much of its organic character as to render the water unfit for use when it rose to its level.

IV. *A well half a mile northeast from last.*

1.	Surface soil	4 feet.
2.	Clay with a granite bowlder weighing 500 pounds	6 "
3.	Clay with gravel	3 "
4.	Hard, dark-blue, shaly clay, with a large piece of wood directly under the bowlder	3 "

V. *A well two miles northeast from last.*

Stratification not observed personally. At about fifty feet fragments of wood, one partially burned, were found intermixed throughout a hard, blackish, laminated clay. Below this the usual yellow clay, with gravel, sand and small bowlders was found resting on Niagara limestone.

VI. *A well quarter of a mile southeast of last.*

1.	Surface accumulation	4 feet.
2.	(Absent, owing to denudation).	
3.	Clay with gravel, sand and bowlders	16 "
4. 5.	Carbonaceous, shaly clay, with fragments of wood, one identified doubtfully as Sumac. Disturbed by glacial and alluvial action	6 "
6. 7.	Yellow clay, with gravel, etc.	4 "
8.	Niagara limestone.	

Farley is twenty-three miles west of the Mississippi at Dubuque, and is about 525 feet higher than that point. The elevation at wells III and V is about the same. IV is about twenty-five feet and VI about fifty feet lower. The general topography beneath the Forest Bed, so far as it has been determined, is not greatly different from that of the present surface. The wells given are but examples of all excavated in the neighborhood, leaving out those in which either the Forest Bed or both it and the older Drift have been removed or modified. The interesting fact is, that the uppermost deposit is in all cases the same, and is beyond the shadow of a doubt glacial Drift very slightly or not at all modified, and exhibiting no distinct stratification. The only difference between the upper and lower parts is that the lower part contains a larger proportion of gravel and worn bowlders from the immediate vicinity. The upper part contains no bowlders indeed except those of granite, syenite, quartzite, and other metamorphic rocks from far to the northward. These, however, are quite abundant. In some fields it has been necessary to remove dozens of bowlders of one hundred pounds weight and upwards from each acre before the land could be ploughed. Some also are quite large, reaching scores of tons in weight. This, too, is a region which our last State Geologist, by some oversight, described as being destitute of bowlders.* But from an examination of many counties noted for the abundance of their bowlders, the writer has found that these erratics are as abundant throughout a great part of the "bowlderless region" as in any part of Iowa. Glacier-marked bowlders are rare, however. Perhaps one in a thousand shows plainly grooves and deep scorings; but many others are less distinctly marked. Still not more than one-tenth exhibit any other marks of glacial action than a rounded form.

The Forest Bed is found at many other localities in Iowa, and within it the bones of the mastodon and beds of peat have been discovered.† The writer has also seen crania of *Bison latifrons* from the same horizon. It has generally been considered to be—in other places as well as in Iowa—a post-glacial formation. This view finds some support in the character of the superficial deposits of Ohio, Illinois and Indiana, from the assorted and stratified arrangement of the later Drift forming these deposits. As before stated, however, the formations in this neighborhood are such as to show conclusively that the Forest Bed is overlaid by true glacial Drift, and hence must be of interglacial age; and from a recent examination the writer is convinced that the overlying deposits in Illinois at least are formed of glacial Drift deposited since the Forest Bed stratum and afterwards modified by alluvial action during the slow retreat of the glacier. In Nebraska this carbonaceous stratum has been found resting on glacial Drift and overlaid by both the Drift of the later glacier and the Lœss of the Missouri Valley.‡ The similarity of the organic remains found in this stratum wherever exposed indicates a like age for its deposits over the whole territory in which it is found.

* Dr. C. A. White's Geol. Rep. (of Iowa), 1870, vol. i, p. 87.
† L. c., pp. 117, 118, 119, and 339.
‡ "Superficial Deposits of Nebraska;" from Hayden's Report for 1874, p. 5.

Farley, Iowa, March 12th, 1878.

ART. L.—*Geographical and Geological Survey of the Rocky Mountain Region under the direction of Professor J. W. Powell. Account of work performed during the year* 1877.

ABOUT the middle of last May, the surveying corps again took the field. This year the rendezvous camp was at Mount Pleasant, a little town in Utah about 125 miles south of Salt Lake City. Three parties were organized under the direction of Professor A. H. Thompson, one to extend the triangulation and two for topographic purposes, the latter being under charge of Mr. W. H. Graves and Mr. J. H. Renshawe respectively, and the former under the immediate direction of Professor Thompson, assisted by Mr. O. D. Wheeler.

The area designated for the season's work lies between 38° and 40° 30′ north latitude, and between 109° 30′ and 112° west longitude, Greenwich, and is embraced in atlas sheets 86 and 75.

Triangulation.—The triangulation party left Mount Pleasant in June. The work of this year being a continuation of the expansion from the Gunnison Base Line measured in 1874, it was desirable to first visit some of the geodetic points established in previous years but the unprecedented amount of snow yet remaining in the high plateaus and mountains rendered this impracticable, and the first part of the season was spent in establishing stations on the Ta-vá-puts Plateau west of the Green River. In midsummer the party was able to visit the high plateaus and connect the work of past years with that of this season. Later the triangulation was extended to the east joining the work of the United States Geological and Geographical Survey of the Territories under charge of Dr. F. V. Hayden and to the north to join the work of the United States Geological Exploration of the 40th Parallel, Clarence King, United States Geologist in charge. The whole area of the season's work embraces something more than 13,000 square miles. The instrument used was the theodolite hereafter described. The points sighted to on the geodetic stations were either artificial monuments or well defined natural points, and all stations were marked by stone cairns.

Topographic Work by Mr. Graves.—The district assigned Mr. Graves for topographic work was the eastern half of atlas sheet 75 and that portion of sheet 86 lying east of the Green and Colorado Rivers, an area of about 10,000 square miles. The most remarkable topographic feature of this region is a bold escarpment facing the south and extending from the western, far beyond the eastern limit of Mr. Graves' work. This is known as the Book Cliffs. At the foot of this escarpment lies a narrow valley through which passes the only practicable route of travel between Central Utah and Western Colorado. South of the valley the whole region is cut by a labyrinth of cañons, formed by the Grand, Green and San Rafael Rivers and their tributaries. This region is one of the most inhospitable and inaccessible in the territory of the United States. It is characterized by extreme aridity, and some portions are cut by narrow gorges, forming "alcove lands." In other portions are found hills of naked sands and clays—regions of bad lands, bold cliffs, towering monuments, hills of drifting, glittering sands and deep tortuous cañons giving to the landscape an appearance strange and weird.

The Book Cliffs rise to an average altitude above their base of 3,000 feet, and about 8,500 feet above the sea-level, and the country from the southern crest inclines gently northward to the valleys of the White and Uinta Rivers. This gigantic terrace, called the Ta-vá-puts Plateau, is cut in twain from north to south by profound gorges through which the Green River runs, known as the cañon of Desolation and Gray Cañon. The drainage of the plateau is northward from the brink of the cliffs through deep narrow cañons for many miles, but at last all these enter the Cañon of Desolation a few miles from its head. North of the Ta-vá-puts Plateau are the valleys of the White and Uinta Rivers. Nearly all the latter and a large portion of the lower course of the former are within the boundaries of Mr. Graves' work.

Over the whole district assigned to Mr. Graves he extended the secondary triangulation. Owing to the peculiar topography of the country, his stations will average about twelve miles apart. He also made a connected plane-table map of the whole area, and complemented his work with orographic sketches.

In the southern portion of the area surveyed by Mr. Graves, considerable bodies of irrigable lands are found along the Grand, Green, San Rafael and Price Rivers; and in the valleys of the Uinta and White Rivers, are other large tracts, on which the waters of the streams named can be conveyed at slight cost. Mr. Graves determined the extent, character and location of these lands, and the amount of water carried by the streams throughout the area embraced in his work.

On the Ta-vá-puts Plateau are small forests of pine and fir, but generally Mr. Graves' district possesses no more timber than sufficient to meet the future local requirements of actual settlers.

Topographic Work by Mr. Renshawe.—The district assigned Mr. Renshawe was the western portion of atlas sheet 75, an area of about 6,000 square miles. The eastern portion of this area is a broad table-land called the Wasatch Plateau, having an average elevation of about 9,500 feet, cut by deep valleys and drained from its very western edge toward the east by the Fremont, San Rafael, Price and Uinta Rivers. The western portion includes broad valleys, abrupt ranges of mountains, and one plateau of considerable extent. The principal valleys in this part are the San Pete, Juab and Utah, all having a general northern and southern trend, an average elevation of about 5,000 feet, and all are drained by the San Pete River and the streams flowing into Utah Lake. The mountain ranges standing between the valleys are the Wasatch, rising in its highest peaks to 12,000 feet, the Lake Mountains and the Tintic Hills each reaching an altitude of nearly 7,500 feet.

The lofty table-land called Gunnison Plateau has an area of about 750 square miles, and an average elevation of 8,000 feet. It is bounded on three sides by almost vertical walls, and is extremely rugged and difficult to traverse.

There is but little irrigable land in the eastern portion of Mr. Renshawe's district, but the broad valleys of the western contain large areas of excellent lands, and the numerous streams furnish a good supply of water.

Mr. Renshawe determined the volume of water in every considerable stream as well as the extent and localities of the irrigable lands throughout his district.

On the plateaus and mountain ranges are large quantities of excellent timber.

On the head waters of the Price River and on Huntington Creek are extensive beds of coal, and on that portion of the Wasatch Range included in Mr. Renshawe's district are deposits of silver and galena.

Mr. Renshawe extended the secondary triangulation over the whole district assigned him, making stations at an average distance of about eight miles, and measuring all the angles of nearly every triangle in the extension. He also made a connected plane-table map of the whole area, and complemented his work with a complete set of orographic sketches.

Hypsometry.—The hypsometric work of this season rests on a primary base established at the general supply and rendezvous camp at Mount Pleasant, and connected by a long series of observations with the station of the United States Signal Service at Salt Lake City. At the base station observations were made with mercurial barometers four times each day, and for eight days during the month, hourly from 7 A. M. to 9 P. M. Mercurial barometers were carried by each field party, and observations made to connect every camp with the base station. All the geodetic points and topographic stations were connected by observations with mercurial barometers either with the camps or directly with the base stations or both. All the topographic stations were also connected with each other by angulation, and from these stations the altitudes of all located points were determined by the latter method.

Instruments. Base-measuring Apparatus.—The apparatus used in measuring the base lines from which the primary triangulation is developed consists essentially of wooden rods aligned and leveled on movable trestles or tripods, the contact being made by coincidence of lines instead of by direct abutment.

The rods are fifteen feet long, one-half of an inch square, thoroughly dried, oiled and varnished. They are supported in cases made truss-form to prevent sagging, and moved in these cases to make the contact by a rack and pinion motion. Either end of a rod is shod with a plate of brass firmly fixed upon and half the width of the rod or one-fourth of an inch, and so arranged, that the plate upon the forward end of any rod projects by the plate upon the rear end of the preceding one, in such a manner that both rods are in the same straight line. The line of coincidence is marked upon both plates and contact is determined by a magnifier. A delicate spirit-level is attached to each case to adjust it horizontally and a thermometer inserted to determine the temperature of the rod. Two steel pins by which the rods are aligned are fixed on the cases directly over the center of the ends of the rods.

The tripods (or stands upon which the cases carrying the rods rest), have short double legs of the usual construction. Firmly fixed upon the tripod heads are two uprights upon which a sliding cross-piece is clamped by thumb screws. Above this cross-piece parallel to and carried with it, is a second which can be moved up or down three-fourths of an inch by means of a long, slender wedge, working between the two cross-pieces and furnishing an easy means of making the final adjustment of the rods in level. The uprights are several inches apart and give sufficient range to all the rods, which is done by a theodolite placed in advance upon the line to be measured. Two or three rods and six or eight tripods are used. The rods are kept in a horizontal position, and when the inequalities of the ground demand, vertical offsets are made with a theodolite. The line is first ranged out and stakes set 500 feet apart along its length, then with six men to work the apparatus, 3,000 feet per day can be measured with all the accuracy the refinements of the triangulation demand.

Theodolite.—The theodolite used in the triangulation is of a new pattern, embracing a number of improvements demanded by the character of the work. So far as possible the number of parts has been reduced by casting in a single piece parts that are usually combined by screws. In this manner the liability to derangement incident to the vicissitudes of mountain work is greatly reduced. The telescope has been enlarged, as compared with the graduated circle, so as to make its defining power bear a greater proportion than usual to the refinement of graduation. The object-glass has an aperture of two inches, and a focal length of twenty. The horizontal circle is ten inches in diameter, and reads by double verniers to five seconds of arc. The vertical circle is five inches in diameter, and reads to one minute. The instrument also embraces other improvements designed to secure greater stability with ease and rapidity in manipulation.

Plane-Table.—In the topographic work the gradientor and sketch book have been superseded by the plane-table and the orograph. The plane-table in use is of a pattern designed by Professor Thompson especially for work of this character. The drawing board is made of a series of slats firmly fixed to canvas in such manner that it can be rolled into small compass for transportation, but when unrolled for work it is so secured by cross-pieces and screws, that great stability is attained. When in use it is fastened to the platen of the orograph. The position of important features in the topography is fixed with an alidade by the usual methods of intersection and resection. Details are placed directly upon the map while they are still under the eye of the topographer, and much of the labor and uncertainty of description by notes is avoided, and the experience of five years in its use has demonstrated that the plane-table, as modified, is equally well adapted to regions of mountains, hills, plains or plateaus. The sketches produced are actual maps and not mere map material. They need only to be adjusted in conformity with the triangulation, and but slight adjustment is necessary. And it has been further demonstrated that a topographer in one field-season can extend his work over an area of about seven thousand square miles, and with all the accuracy necessary for the scale adopted by the Interior Department for the physical atlas of the Rocky Mountain region, that is, a scale of four miles to the inch.

Orograph.—The orograph is an instrument new to topographic surveying, adapted to the requirements of this work by Professor Thompson. It consists essentially of a telescope erected above a platen or drawing-board, on which the movements of its optical axis are recorded. The telescope rotates about a vertical and about a horizontal axis similarly to the telescope of a theodolite, and is connected by simple mechanism with a pencil which rests on a sheet of paper attached to the platen. When the topographer moves the telescope so as to carry its optical axis over the profiles of the landscape, the pencil traces a sketch of the same. This sketch being mechanically produced, is susceptible of measurement, and is a definite and authoritative record of the angular relations of the objects sketched. The instrument is also furnished with a graduated circle on which horizontal angles may be read to the nearest half minute, and this circle is used for the secondary triangulation. The orograph and plane-table are used conjointly, and their results furnish data for the production of contour maps. It is believed that by their introduction the quality of topographic work has been much improved, without addition to its cost. When a topographer takes the field with these two instruments and plane-table sheets on which the primary triangulation has been previously plotted, he returns with a map on which all of the geographic features to be delineated have been determined by their angular relations and the scenic characteristics necessary to give proper effect to the maps, have been outlined by instrumental means. In this manner the subsequent construction of maps at the office ready for the engraver is reduced to a minimum of labor, while for the proper accuracy the topographer is not necessitated to resort to his memory for the appearance of the landscape, but only to the definite record.

Barometers.—The instruments used in the hypsometric work are Green's mercurial mountain barometers, Green's psychrometers and aneroid barometers of the usual construction.

Cartography.—Much attention has been given to this subject for the purpose of determining the best methods of representing the topography of the region surveyed, taking into consideration the character of the country, the more important facts to be embodied, and the scale adopted for the Physical Atlas of the Interior Department. The systems of cartography in use in this country and many of those of Europe have been examined and studied, and many experiments have been made in the office for the purpose of determining the best methods adapted to these circumstances and conditions.

For the Physical Atlas heretofore mentioned, it is proposed to represent the topography by contour lines with auxiliary hatchings to indicate rock surface, and shading for general reliefs, these so applied as not to obscure the contours. For special purposes hatched maps are used, for others contour maps, and for purposes relating to the discussion of geological structure, maps are made by photographing or lithographing models or relief maps in plaster.

Classification of Lands by Mr. Gilbert.—The Survey under the direction of Professor Powell has been extended over the northern portion of Arizona and the greater part of Utah, but a broad strip along the northern end of the latter Territory was embraced in the survey made by Mr. Clarence King, under the War Department. It seemed desirable, however, to extend the classification of lands over this latter region, and this duty was assigned to Mr. G. K. Gilbert.

Mr. Gilbert took the field at Salt Lake City, and traversed all of the Territory lying west, north and northeast of that point, a tract comprising so much of the drainage basin of Great Salt Lake as lies in Utah. In this area is included the most valuable portion of the Territory, as well as one of the most sterile. A very small part of it will repay cultivation without irrigation, but this is exceptional, and in general the possibility of agriculture depends upon the possibility of artificial watering. The Bear River, the Weber, and the Jordan carry as much water as can profitably be used upon all the lands to which it is practicable to convey them by canals, and these lands were measured in order to determine the agricultural capacities of their valleys. The smaller streams, on the contrary, are inadequate to serve the arable lands through which they severally run, and their agricultural capacities were ascertained by measuring the volume of each stream. East of Great Salt Lake are great mountain ranges, the Wasatch and the Uinta, and large streams flow from their melting snows all through the summer season. The Bear, the Weber, and the Jordan flow to the lake, and the three rivers can be made to reclaim 800,000 acres of land in their valleys. This is twelve and one-half per cent of the district that they drain. West of the lake the plains are interrupted by mountains of great magnitude, the snows of winter are dissipated too early in the spring to be of use for irrigation, and much of the land is an absolute desert. In a total area of 8,300,000 acres only 21,000 acres are of value for farming—one-fourth of one per cent.

These estimates are based upon the experience of the farmers of the district, who have practiced irrigation for thirty years, and have given it a greater development than can be found elsewhere in the United States. They have now under cultivation a third part of the irrigable lands of the Salt Lake Basin, and are utilizing many of the small streams to the full extent of their capacities. A careful study was made of their operations, for the purpose of learning the quantity of water necessary to redeem a given quantity of land under various conditions of soil and climate, and the resulting determinations were used in computing the areas susceptible of irrigation by the streams and parts of streams unused. The greater part of the future extension of the cultivated areas will be accomplished only by expensive engineering works, including the damming of the principal rivers and the construction of long canals. Five million dollars is probably a moderate estimate of the cost of redeeming the 500,000 acres that are susceptible of reclamation, and the requisite capital will have to be concentrated upon a small number of large canals.

Since the first settlement of the territory in the year 1847 the water supply has increased. It is reported by the citizens that each stream is now capable of irrigating a greater area of land than when it was first used. Creeks that once scantily watered a few acres of ground now afford an ample supply for double, treble, and even fifty times the original area. This increase has been accompanied by a rise of Great Salt Lake, which having no escape for its water except by evaporation has stored up the surplus from the streams.

For the purpose of investigating the extent and the cause of the increase of the streams, Mr. Gilbert made a study of the fluctuations of the lake. It was a matter of common report that the surface of the water had been subject to considerable changes and that on the whole it had greatly risen since its shores were first settled; but previous to the year 1875 no systematic record of its movements had been kept. In that year a series of observations was inaugurated by Dr. John R. Park of Salt Lake City, at the suggestion and request of the Secretary of the Smithsonian Institution. A small pillar of granite, graduated to feet and inches, was erected at the water's edge near a rocky islet known as Black Rock. The locality was then a popular pleasure resort, and the record was undertaken by Mr. J. T. Mitchell. Observations were made at frequent intervals for more than a year, but were then interrupted by reason of the disuse of the locality as a place of resort, and they have not since been resumed in a systematic way. To obviate a similar difficulty in the future, Mr. Gilbert caused a new record post to be established near the town of Farmington, where the work of observation has been undertaken by Mr. Jacob Miller, and it is anticipated that in the future there will be no break in the continuity of the record.

In the interval from 1847 to 1875, during which no direct observations were made, there was nevertheless a considerable amount of indirect observation incidental to the pursuits of the citizens. The islands of the lake were used for pasturage, and the facilities for the transfer of cattle to and fro were greatly affected by the fluctuations of the water. A large share of the communication was by boat, and the frequent changes of landing place which the boatmen were compelled to make impressed upon their memories the character and order of the principal oscillations. In pursuance of the inquiries instituted by the Secretary of the Smithsonian Institution, the testimony of the boatmen was compiled by Mr. Jacob Miller and a history of the oscillations was deduced.

A similar and corroborative history has been derived by Mr. Gilbert from an independent investigation. Two of the islands used for pasturage are joined to the main land by broad, flat bars, and during the lower stages of the lake these bars being either dry or covered by a moderate depth of water, have afforded means of communication. It happens that the Antelope Island bar was in use until 1865, when it became so deeply covered that fording on horseback was impracticable; and that the Stansbury Island bar was first covered with water in 1866, and has been used as a ford, with slight exception, ever since. By the compilation of the testimony of those who have made use of these crossings, a continuous record was derived, which cannot deviate very widely from the truth, and the work was checked by making careful soundings to ascertain the present depth of water on the Antelope Island bar.

From 1847 to 1850 there was little change beside the annual tide variation dependent upon the spring floods, and which makes the summer stage in each year from one to two feet higher than the winter. Then the water began to rise and so continued until in 1855 and 1856 its mean stage was four feet higher than in 1850. This progressive rise was followed by a progressive fall of equal amount, and in 1860 the lake had returned to its first observed level. In 1862 there began a second rise which continued for eight years and carried the water ten feet above the original level. Since 1869 there has been no great change, but the mean height has fluctuated through a range of about two feet.

As the lake has risen it has encroached upon the land, and the shores are in many places so flat that large areas have been submerged. At one point the water edge has advanced fifteen miles, and the surveys of Captain Howard Stansbury and Mr. Clarence King show that from 1850 to 1869 the total area of the water surface increased from 1,750 to 2,166 square miles, or nearly twenty-four per cent. By this expansion the surface for evaporation was increased so that the lake could return to the atmosphere the surplus thrown into it by the augmented streams.

Whatever land is at any time flooded by the lake becomes saturated with salt, and if the water afterward retires, remains barren of vegetation for many years. The highest level reached by the water in storms is marked by a line of driftwood and other débris. Above this line there is usually a growth of grass and sage brush, but below it nothing grows. Previous to the last great rise of the lake, the storm line was six feet lower than at present, and the intervening belt of land still retains the stumps and roots of bushes that have been killed by the advancing brine. The encroaching water overran the ancient storm line in about the year 1866, and for the past eleven years it has covered ground which had been exempt from incursions of brine for a time sufficient to permit the rains to cleanse the soil, and for a further time sufficient to produce a growth of sage brush. The whole period is as likely to have been measured by centuries as by decades.

Thus it appears that the last twelve years have witnessed an extension of the lake, which is not only without precedent in the experience of the citizens of Utah but is clearly an anomaly in the history of the lake. To explain it and to explain at the same time the increase of the streams, there are two general theories worthy of consideration.

The first is that there has been a change of climate in Utah whereby the atmosphere is moister, so that the fall of rain and snow has become greater and the rate of evaporation has become slower. The second is that the industries of the white man, which have been steadily growing in importance for the last thirty years, have so modified the surface of the land that a larger share of the snow and rain finds its way into the water-courses and a smaller share is returned to the air by evaporation from the ground. The latter theory, which is the one proposed by Professor Powell, is considered by Mr. Gilbert the more probable, and he finds reason to believe that the tax imposed upon the streams by the work of irrigation is more than repaid by the effects of the draining of marshes and the destruction of herbage and timber. A great volume of water is turned upon the cultivated fields, and from their moist surfaces is absorbed by the atmosphere without ever reaching the lake; but on the other hand the farmer has found it to his advantage to drain the beaver ponds and other marshes and thus check the evaporation from their surfaces, and the streams which he thereby rescues from dissipation are used in irrigation for a few months only, while for the remainder of the year they pay their tribute to the lake. The destruction of grasses by herds of domestic animals and the cutting of trees upon the mountains expose the ground to the sun and facilitate the melting of the snow; the removal of the grass opens the way also to a freer circulation of surface waters, so that the rain and melting snows are gathered more quickly and thoroughly into rills and streams; and both these influences increase the inflow of the lake.

This discussion has an important bearing upon the agriculture of the arid region, for if the theory favored by these gentlemen is the true one, the work of irrigation can be pushed forward with the confident assurance that the supply of water is more likely to increase than diminish in the future; and it may even be possible when the subject has been fully developed, to devise measures which shall directly promote the increase.

Geological work by Mr. Gilbert.—During the preceding summer Mr. Gilbert had discovered a peculiar series of phenomena produced by recent orographic displacements, and he has this year found opportunity to study them in numerous new localities. It appears that the system of faults and flexures—the system of upward and downward movements—by which the mountain ranges and the valleys of Utah and Nevada were produced have continued down to the present time. Evidence of recent movement has been discovered on the lines of many ancient faults. The ancient shore line of Great Salt Lake which is exhibited so conspicuously upon the surrounding mountain slopes, and which must have originally been level, is no longer so, but has been shifted up and down by the displacement of the mountains. Its present altitude above Great Salt Lake was determined at four different points by spirit-level; and the determinations were found to range from 966 feet to 1,059 feet. The measurements by level were all made in the immediate vicinity of the lake, but the barometer indicates that at points more remote the discrepancy is greater.

These observations are valuable additions to our evidence that mountain-making is a work of the present as well as of past ages, and that the grand displacements by faults and folds are caused by slow intermittent movements.

Mr. Gilbert also traced and mapped the northern portion of the ancient shore line of the Lake from Salt Lake City to Redding Spring, following its sinuous course for 900 miles in Utah, Idaho and Nevada, and demonstrating that the ancient outlet he had discovered the preceding summer at Red Rock Pass was the only one by which the lake had ever discharged its water to the Snake River.

During the winter of 1876–77, Mr. Gilbert prepared his Report on the Geology of the Henry Mountains, and the manuscript was sent to the printer.

The Henry Mountains constitute a small group in Southeastern Utah and stand quite by themselves. They are of a peculiar character and represent a type of structure that has never before been fully described. Mr. Gilbert's report is a monograph at once of the mountain group and of the type of mountain structure. The mountains are of igneous origin, but the rising lavas, instead of outpouring at the surface of the earth, in the usual way, failed to penetrate the upper portions of the crust and formed subterranean lakes or chambers. The strata lying above the lava lakes were upbent in the form of great bubbles, and from these bubbles of sandstone and shale with their cores of trap, the erosive agents of the air have carved the mountains. The mountain structure is thus twofold, comprising first volcanic upheaval, and second atmospheric and aqueous degradation. To aid in the discussion of the first element of structure, Mr. Gilbert constructed a stereogram of the district in plaster, exhibiting the forms due to upheaval as they would appear if unmodified by degradation. He prepared also a topographic model, exhibiting the same forms as actually modified; and the two models will be reproduced by photography to illustrate the report. The treatment of the second element of structure is of a thorough character and includes a discussion of the general principles which control the sculpture of the land surfaces of the earth by rains and rivers. The volume is ready for the binder.

Geological work by Captain Dutton.—Captain Dutton resumed his exploration of the same field which he has been studying for three years, having recognized in it a certain unity which renders it eminently adapted to an important monograph. The region explored by him is centrally situated in the territory of Utah, extending from Nebo in the Wasatch nearly southward a distance of about 180 miles and having a maximum breadth of about 60 miles. It possesses certain features which serve to distinguish it both topographically and geologically, and he proposes to call it the District of the High Plateaus of Utah. It consists of a group of uplifts now standing at altitudes between 9,000 and 11,500 feet above sea-level, while the general platform of the country is from 5,000 to 7,000 feet high. The plateaus have been carved out of this platform by great faults, and the general structure corresponds closely to that described by Professor Powell under the name of the Kaibab structure and illustrated by him in his section of the region traversed by the Grand Cañon of the Colorado. The relations of this belt of high plateaus to the regions adjoining are of special interest. At the close of the Cretaceous, the country lying to the eastward of it passed by gradation from an oceanic to a lacustrine condition, the intermediate stage presenting doubtless a strict analogy to the condition of the Baltic. This Eocene lake area now constitutes the southern part of the drainage system of the Colorado River. During Cretaceous and Eocene time the area now occupied by the Great Basin was dry land, and its denudation must have furnished a large part of the sediments which were spread over the bottom of the great lake. The movements, which took place during the Eocene, at last resulted in the desiccation of the lake, and though a strict chronological correlation to European and other divisions of time cannot be made with certainty, it may be provisionally inferred that this desiccation was completed before the commencement of the Miocene. It was brought about by the more rapid uplifting of the lake area than that of the Great Basin until at last the former area became the loftier of the two, thus reversing their relative altitudes. The lake area is now a portion of the so-called Plateau Country and since the commencement of the Miocene (para-Miocene) has been subject to a great and continuous erosion. The district of the High Plateaus occupies a portion of a narrow belt separating the Plateau Country from the Basin Province and therefore stands upon the locus of the ancient shore line which in the lacustrine stage bounded the two areas. To that shore line they stand in an intimate and remarkable relation. To its trend the great displacements maintain not merely general parallelism but an approximation to strict parallelism both in totality and in detail which would not have been anticipated and which cannot be purely accidental, and seems to point to some definite determinative association between the littoral deposits and the great lines of displacement. The great structural features are these faults and their equivalent monoclinal flexures. They are remarkably persistent, extending in parallel courses throughout the entire length of the region surveyed. One of them, the great Sevier fault, becoming here and there a monoclinal flexure, has been traced continuously over a length of 240 miles, and others of nearly equal persistence have been noted. The High Plateaus belong to the Plateau Country, for notwithstanding the great amount of dynamical energy displayed in their uplifting they preserve in a remarkable manner the plateau type of structure, which is distinguished sharply from the arched, flexed and tilted types prevailing in other disturbed localities. There is an abrupt transition from this plateau structure to that found in the adjoining Basin. There are some localities where one may hurl a stone from one province to the other, and in general it may be said that the dividing line must pass within a single range or table. The Plateau Province seems to stand here in strict correlation to the Tertiary beds; where the tertiaries end there also end the plateaus. The relation between the Tertiary and Cretaceous throughout this belt is one of general unconformity; in many places where the contacts are seen the Tertiary is revealed lying across the upturned and eroded edges of the Cretaceous, showing clearly a break between those portions of the two series which are here preserved.

But of all the features displayed by the High Plateaus the most remarkable are the manifestations of former volcanic activity. Both in area and thickness the volcanic emanations are very extensive. They cover more than 5,000 square miles, and sections of 4,000 to 5,000 feet are presented without revealing the lowest beds. The greater part of the eruptions took place after the lake basin had been drained or had shrunken to limits outside of the district, for sedimentary beds have not been found intercalated between the various flows but always underlie them. It is therefore impossible to fix with great precision the commencement of the outbreaks, but the general indications are, that they began very soon after the close of the lacustrine period, and they may have commenced still earlier. The eruptive epoch was undoubtedly a long one. The individual flows are very numerous and represent all the great groups of eruptive rocks. In many cases the quantity of material extravasated is so great that the eruptions may well be called massive, not however of such marvellous extent as asserted to have been poured forth from fissures during the Basaltic period in Oregon and Northern California; but there are many individual sheets which surpass in magnitude any which is known to have emanated during recent or modern times from any existing volcanic vent at a single eruption. From what openings these masses were extravasated it is usually difficult to fix with certainty and precision, so vast are the accumulations and so expansive are the sheets, and at the same time so numerous that wheresoever they were emitted the earlier vents must have been buried by later deluges of lava, and even the more recent vents, except in the case of the latest basalts, have been swept away by slow erosions in the long period which has elapsed since their activity was extinguished. There are, however, still remaining, distinct traces of localization of eruptive activity in the form of greater accumulations, at some points, from which in most directions the total thickness of the volcanic series appears to attenuate. Moreover in those central localities of maximum accumulations there appears to be a large amount of what might be called in a certain sense unconformity of the various eruptions, and greater irregularities in their bedding as compared with the more even layers and more regular distribution of the sheets more remote from these centers. This fact appears to be of general application also to existing volcanic regions of great extent. Captain Dutton has succeeded in locating at least five areas from which the various overflows appear to have emanated, and believes that further research might result in the determination of many others.

At the time these eruptions were in progress it is probable that the country was not an elevated one as at present, though it might have been a rising area. The great displacements consisting of immense faults of extraordinary length and persistency took place after the close or during the decadence of the principal eruptions, and it was at this latter epoch that the greater part of the general elevation of this portion of the Plateau Province occurred. During its progress many eruptions must have taken place, and their later age is readily identifiable, but none of them were comparable in extent and in the volume of ejected materials with older eruptions prior to the great displacements. Although it is ordinarily not difficult to determine whether a particular event preceded or followed some other event within the locality, there seems to be no way of correlating these different events strictly with the epochs which are designated by the sedimentary formations of the adjoining country, and it is therefore impossible to determine the exact period in the chronological scale, at which the faulting took place, further than the fact that it must have occurred long enough after the close of the Eocene to allow for the accumulation of these vast bodies of volcanic beds. This may carry the period of faulting far into the Miocene period, or possibly as far as the commencement of the Pliocene. But while the first stage in the activity of these ancient volcanoes was undoubtedly the greatest and accompanied by an incomparably greater amount of extravasation, it by no means constitutes the the whole of it. Even after the great displacements and after the principal topographic features of the country depending upon structure as they now exist had received their shape, minor eruptions continued. They present, however, a somewhat remarkable fact. The later eruptions did not take place from the same centers as the earlier ones, but show a tendency to recede from them and to occur around the borders of the older volcanic district. The central portions of the volcanic area are unquestionably the oldest, while the younger ones are found around their borders and sometimes at considerable distances.

One point which during the study of this region has engaged the careful attention of Captain Dutton, has been to ascertain whether it presents any such sequence in the lithological character of the eruptions as is asserted by Baron Richthofen to prevail in the volcanic districts of Europe, South America, Asia Minor, and the Sierra Nevada. This asserted sequence has engaged the profound attention of most vulcanologists and is of great importance in relation to all questions bearing upon the origin and causes of volcanic action. Although at first disposed to doubt the prevalence of this sequence, and not favorably impressed with the speculations and theoretical views of Baron Richthofen, Captain Dutton has reached the conclusion that the high plateaus of Utah exhibit in a decided manner essentially the same sequence which Richthofen claims for other volcanic regions. The earliest eruptions consist of rocks agreeing well in lithological characteristics with those described by Richthofen under the name of propylite. This rock is usually concealed, if it exists in any great quantities, by the later flows, but is in several places brought to light partly by the great displacements and partly through the agency of erosion, and wherever found it is seen to occupy the lowest position of all. It is also worthy of note that this rock is found at those points which constitute the centers of eruption before referred to, showing that the activity which it ushered in continued to have its seat through a long cycle in and about the same locality. The propylite is succeeded by a rock answering to Richthofen's description of hornblende andesite, which is usually overlaid by a rock rich in augite with triclinic feldspar, which may be termed augitic andesite. Still higher in the series are found immense masses of trachyte which, however, is frequently intercalated with dolerite. The variety of the trachytes is very great—so great indeed that were it not for the persistence of certain mineralogical as well as textural characteristics, which are universally accepted as being distinctive of that group of rocks, one might feel strongly tempted to make numerous subdivisions of them. The extremes of the varieties of the trachytes might be represented at one end by a coarsely granular micaceous rock composed chiefly of orthoclase, sometimes hornblendic and sometimes augitic; at the end is a highly porphyritic trachyte, consisting of well-developed orthoclase feldspar imbedded in a fine paste highly charged with peroxide of iron. Between these masses of trachyte are intercalated, though in subordinate quantities, beds of dolerite, showing distinct crystals of striated feldspar, with great abundance of augite and magnetite. In the earlier and grander periods of the eruptions the following sequences may therefore be recognized: first, propylite; second, andesite; and third, interblended trachyte and dolerite. Still later than these and occurring at new centers of eruption were outpours of rhyolite, while last of all were erupted around the outskirts of the district great quantities of true basalt. There does not appear to be any single locality where all the groups of rocks are found superposed; nevertheless the relative ages do not admit of any doubt, whether the beds are superposed or not; but while furnishing a general verification of the sequence, the district of the High Plateaus presents the fact with certain modifications which may be set forth in the following manner. In the lithological scale, propylite and hornblendic andesite are very nearly intermediate between the extremes of acid rocks represented by rhyolite, and basic rocks represented by basalt. Taking propylite as a starting point in the scale of classification, we find two divergent series proceeding on the one hand toward the acid end of the scale, and on the other toward the basic end. As we follow the eruptions down into the later epochs we find that both series are represented in a certain sense independently of each other, so that they intercalate; the acid becoming at one end more acid with the progress of the volcanic cycle, and the basic rocks becoming more basic. Each series seems to pursue its own order and to be subject to its own law, so that being originally divergent, they become more and more widely separated in their lithological characters, as the cycle proceeds. Thus at the commencement of the activity we have propylite and hornblendic andesite, which are closely assimilated to each other in their physical characteristics; at the middle stage we have trachytes and moderately basic dolerites, which are moderately separated, and at the close we have rhyolites and basalts, which stand at the opposite ends of the scale.

Plan of Publication.—In the geological branch of the work, the plan has been adopted, as far as possible, of publishing monographs, each embracing all the studies made by the corps of any particular region to which it relates, preferring this to a system of annual reports consisting of *résumés* of the field notes of each season. In the preparation of these monographs, relief maps or plates are constructed on a scale of two miles to the inch or larger, vertical and horizontal scales being equal, and to correspond with each relief map a stereogram in plaster is constructed on the same scale, designed to exhibit such surface as would appear had there been no degradation by atmospheric agencies, but displacement can be studied independently of the phenomena of degradation, with which in nature they are always associated, and by which they are more or less obscured; and a comparison of the stereogram with the relief map gives approximate quantitative results of degradation; that is, the two factors of mountain structure, elevation by displacement and degradation by rains and rivers are separated, that each may be considered independent of the complicating conditions of the other.

Geological Illustration.—Much attention has been paid to the graphic representation of the important features of geological structure. The Rocky Mountain region has proved to be one of great interest in this branch of investigation, because of the peculiar features of its physical geography. Long and towering escarpments are found, deep cañons with precipitous walls are numerous, its hills and mountains are often without soil and vegetation, accumulations of sub-ærial or glacial drift are infrequent, and thus the general rock-structure is well revealed. Several new methods of illustration have been devised, some of which have already appeared in the publications of the Survey.

[To be continued.]

ART. LI.—*Just Intonation in Music. Its Notation and Instruments;* by HENRY WARD POOLE, M.A., of South Danvers, Massachusetts; and Professor in the National College of Mexico.

IT is evident that there is a general want of intelligence concerning the fundamental laws of Musical Intonation, the constitution of the so-called scale and the means of attaining practically just melodies and harmonies. There is doubt still even among those most eminent in acoustics as to whether the *septimal* ratios are admissible in practice. Others who would be glad to have it used, are doubtful whether the nice distinctions of comma, etc., can be recognized and sung. Without reference to previous times, I can declare from abundant personal knowledge, and actual demonstration, that the chord of the seventh is most agreeable and easy to give with the just ratio of 4 : 7, and that there is no practical difficulty in singing in just intervals. There appears to be a general desire expressed for such perfect intonation, and in consequence the following observations may be interesting.

However complicated this subject may appear when studied in books which do not have any primary definitions or canons, it can be made as clear and orderly as naturally it would be supposed, in view of the fact that music is based upon the mathematics.

Classification of Musical Tones into three Principal Orders.—Admitting into music only the prime numbers 2, 3, 5, 7, and considering the 2 as auxiliary, forming octaves, and inversions, but not producing new or original harmonies, there remain three others, which give the *Fifth*, 2 : 3, the *Third* (major always, unless otherwise expressed), 4 : 5, and the *Seventh* (Perfect or Harmonic), 4 : 7. A *series* (each a fifth from the next,) is formed of each of these kinds, and we have three Prime Series. A due mixture of the notes of each is necessary for harmony. Using the letters, C, D, E, etc., we may express the series to which each belongs in various ways. In common notation it is known to the intelligent singer or violinist by his perceiving the relation of each note in the scale. All the strings of the violin, violincello, etc., are tuned to the First series, that of Fifths. The open strings of the violin sound justly only in the key of D. In G they are equally true except the highest, which is a comma too high for the third of C, which is in tune with the open G. In other words, there are two tones with the same name. We have distinguished these by E, the higher, and e, the lower. For greater clearness in writing down the scale, and in its analysis and vocal practice we will color the E, and all of the First series with *Red:* giving to the e, and all of the Second series, the *Yellow*, which, to show well by artificial light will be well done by gold. In like manner, the Third series, that of the Sevenths, indicated by a gothic letter, will be colored *Blue.** Nothing remains but to call the tones by distinctive names. The syllables of Guido answered this purpose when there was no "modulation within the key," and no account made of Perfect sevenths. To the modern syllables belong two, which were not in the original in the "*Ut queant laxis;*" to wit, the "Do," and the "Si." Keeping the Do as it is, and changing the initial letter of the si, so as not to confuse it hereafter with that of sol, we may find a common ending to all the notes of the first series, or that of the Fifths. These are the 1st, 2d, 4th and 5th. Preserving the 1st and 5th as they are, but rejecting the final letter of the sol, and making the rest conform, we shall have Do, Ro, Fo and So. Their *class* is known by the termination; the *place* of each in the scale by the initial consonant. For the second class, that of the Thirds, mi, la, si, we preserve also the present termination of the majority, and have mi, li, and zi. For the Perfect sevenths or Third series, which are generally sounded by the termination of e (Italian), we preserve the same, and zi flat is **Ze**. And the dominant seventh, lower than Fa, will be **Fe**. There are two different Diatonic Scales according as the Seventh 4:7, is introduced or not; they will be expressed in reference to their syllables for singing, their letters, colors, relative vibrations and intervals, as follows:

TRIPLE DIATONIC SCALE.

Common Chords on C, G and F.

	Do		Ro		mi		Fo		So		li		zi		Do
In key of C,	C		D		e		F		G		a		b		C
Colors,	Red		Red		Yellow		Red		Red		Yellow		Yellow		Red
Relative Vibrations,	48		54		60		64		72		80		90		96
Intervals,		8:9		9:10		15:16		8:9		9:10		8:9		15:16	

DOUBLE DIATONIC SCALE.

Common Chord on C; Chord of Seventh (and 9th) on G.

	Fo		So		li		**Ze**		Do		Ro		mi		Fo
Key of C (Tonic F),	F		G		a		**B**♭		C		D		e		F
Colors,	Red		Red		Yellow		Blue		Red		Red		Yellow		Red
Relative Vibrations,	32		36		40		42		48		54		60		64
or	48		54		60		63		72		81		90		96
Intervals,		8:9		9:10		20:21		7:8		8:9		9:10		15:16	

* I had selected for the three Prime Chords, the colors generally considered as Prime; applying to the Green, which has optical claims against the Yellow, the test of the proportional rate of vibration, I find that the *Green really corresponds*, as nearly as could be expected in such a determination, *with the Prime Chord of the Third.* The Red, Yellow, Green, and Blue being as Do, Ro, mi and **Fe** (the dominant 7th), or as the numbers of the Double Diatonic Scale 32, 36, 40, 42, the Violet approximating to the So or 5th. The Yellow in all the tables comes very near to Red as 9:8. The Orange does not appear to have any correspondence in the acoustic scale.

The Double Diatonic Scale has two notes differing from two of the triple scale on the same tonic—which is F; although its tones are all in the key or scale of C, being identical with the Triple Diatonic of C, with the exception of the change of b into **B**^{b}. But its ending and tonic is F. Having thus provided for the notation and distinction of these different series of Primary Tones, and using the colors, we shall find on trial by the ear, or by examination of the music in use, especially when written as here indicated, that at least two different series (or colors) must appear in every chord, or it is wanting in *richness* or effective *ring*. Especially in duets is this observed; the two voices are constantly giving pairs of different colors. The duplicates or notes of the remaining series—there being three—are given by the accompaniment, if there be any. Two hunting horns having to limit themselves to what might be called a "Single Diatonic Scale" (as having but one chord, say of C, with seventh, ninth, etc.,) and making their own fundamental harmony, cannot comply fully with this rule; they give at times fifths, (both red) without any third. The necessity of pure elements in these nice combinations is soon perceived.

For an example in point we may take the triple (or common) diatonic scale, giving to one voice this scale and to another the accompaniment; noticing by the difference of type that each pair is of different series. *Note.*—The 2d and 4th can never accord (D, F, 27 : 32). *Rule.—Tones a third apart*—two degrees—*must be of different series.* (Sixths, being only an inversion of thirds, are subject to the same law.) *Note.*—D, **F**, are harmonious, 6 : 7, and d, F, 5 : 6, are also good: the d is the "grave second" of the old theorists, and is the sixth of the scale of F, and occurs in the natural key in cadences and "modulations within the key."

Scale of C, harmonized.

C D e F G a b C	C b a G F e D C
unison b C a e F G e	e G F e d C b unison

In descending, the F is accompanied by this grave d with natural and easy effect. As this momentary inclination to the subdominant chords is made, so the double diatonic enters, and instead of F, G, e, at close of the ascending scale, we could have F, **F**, e—by syllables, Fo, **Fe**, mi. But never will be seen a chord of the Third (or Sixth) from the same series.

The instruments of just intonation are those of free tones, as the voice, the violin class, and the trombones, etc., and those of fixed tones, as the organ and other instruments to be described.

The Enharmonic Key-board for organs, etc., described in this Journal in July, 1867, while preserving its essential principles, is capable of being varied to embrace more or less series of sounds, and to give to each the prominence desired. I shall describe one which embraces the three series of Prime chords, and, in addition, a Fourth, of the *leading notes to the Thirds* of Series II, which are used in ornamental passages and the "minor mode." The plan is formed by dividing the octave—$6\frac{1}{2}$ inches—into 24 equal parts; the distance of nine-tenths of an inch being laid off from front to back, 14 times, will provide for the tones from C flat to F sharp. All the divisions for the digitals will fall upon these lines, and will be understood by reference to the diagram, the mutual relation being the same in

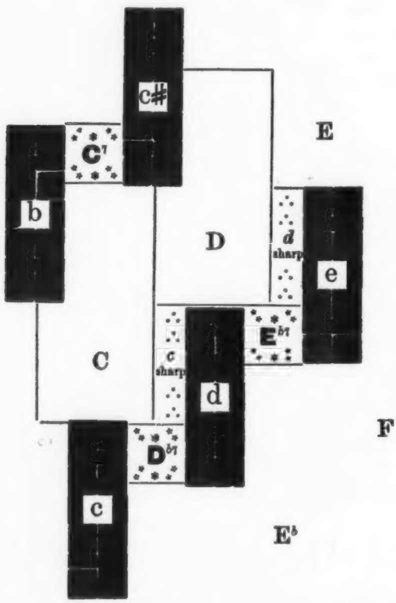


Diagram.—Simply to show the *relative position* of the Digitals of the four Series; their exact sizes being as follows:

$a = 6{\cdot}5$ inches $\div$ 24 ($= 0{\cdot}27$). $b = 0{\cdot}9$.

Series.	Width.	Length.
I. (C, D)	4*a* (and 3*a*)	4*b*
II. (c, d, e)	2*a*	3*b*
III. (C7, E♭7)	2*a*	1*b*
IV. (c♯, d♯)	1*a*	2*b*

all parts of the boards. The digitals of each signature are elevated one-tenth of an inch as they go backward. The base of the digital C, with its 3d, e, and *d*♯, (leading note to e,) and its seventh **B**♭ are $\frac{1}{10}$ of an inch higher than F, a, *g*♯ and **E**♭, and the same distance lower than G, b, *a*♯ and **F**. The white keys of Series I being at this level, the black keys rise 0·45; the orange keys, (Series IV,) are 0·75; and the blue keys of Series III are 0·90. All the elevated keys are reduced in width, down to the base, so as to allow the finger to enter freely between them. The number of digitals being 48, each lever is taken at the half of these primary 24 divisions, and all lie in one level at the rear of the key-board. In construction, the number of pipes (or *vibrators*, in the cabinet organs) is reduced by using the same for those which being at the distance of 8 Fifths and 1 Third are practically identical. (§ 29, 30 this Journal, July, 1867).

Justly-Intoned Pianofortes.—It is desirable to obtain a loud and full tone by a single wire, large and at full tension. Then with an enharmonic key-board and the triple sets of wires, the whole will be easily kept in tune, and will sound louder than if they were tempered.

Wind Instruments of the class of the horn, cornet, etc., depend, for the fundamental tone, on the length of the tube, and for the harmonics, on the tension of the lips. The fundamental length may be varied by the common cornet valves or "pistons" and corresponding supplementary tubes to give the tones of series I. These valves are arranged in the order of the fifths, or thus: F, C, G, D, A, E, B, etc. To play the triple diatonic scale of C will be used the valve of C (or the simple tube of the whole instrument, if so constructed) and those of F and G, on its right and left; the order of these dominants, etc., is the same in every key. For the sake of economy in construction, or to save weight, while playing, there might be four or five valves, and the player before beginning might select the tubes he is going to need, as is done with the simple horn, which can have but one at a time. Any one can try the effect of this system with a common cornet and a pair of tubes —india-rubber will do—which will add to the fundamental tube 50 and 33 per cent for the subdominant and dominant.

The *Trombones* can be rendered not only capable of just intonation, as they now are, but with fixed and certain tones; this can be done in various ways, including a combination of the sliding double tube to fix the tonic, with three valves with their tubes kept in due relation with the tonic—varying as the whole tube is longer or shorter—so as to give dominant and subdominant to any tonic. A change of key is thus made by simply moving the trombone slide to the new key-note.

It is easier to play these enharmonic instruments, than the common tempered ones; the director can mark the changes to be made. Joined with the violins and voices excellent effects will be produced. The clarionets, etc., can be favored by good players so as to fall in with the rest in the just and perfect concert.

ART. LII.—*On certain Forms of Brachiopoda occurring in the Swedish Primordial;* by S. W. FORD.

IN a paper "On the Brachiopoda of the Paradoxides beds of Sweden," published in the Transactions of the Royal Swedish Academy of Sciences, for 1875, M. G. Linnarsson institutes the genus *Acrothele* for the reception of certain Discina-like fossils of the Swedish Primordial, and describes under it two species, *A. coriacea* and *A. granulata.* Upon the characters of these two forms I beg leave to offer a few remarks.

Acrothele differs from *Discina*, according to M. Linnarsson's description, in the absence of the longitudinal slit of *Discina*, the perforation of the apex of the ventral valve, and in its interior markings so far as these have been made out. The shell substance is corneous. M. Linnarsson considers the most nearly related genera to be *Obolella* and *Acrotreta*, but at the time he wrote, shells having a phosphatic test had, as he states, been referred to the former genus. M. Linnarsson gives numerous illustrations of the ventral valve of *A. coriacea*, and one of the interior of the dorsal valve which presents some remarkable features. The perforation in the apex of the ventral valve can, he states, usually be made out only with difficulty owing to its extreme minuteness; and in the description of the ventral valve of *A. granulata* no such perforation is shown to exist. In a later illustration of *A. granulata*,* however, the apex is represented as perforated, but the perforation is so small that a doubt naturally arises as to whether it truly represents an orifice leading into the interior. Nevertheless M. Linnarsson states that in the internal casts of the ventral valve of *A. coriacea* the presence of an umbonal orifice is always readily recognizable. The interior of this valve, so far as known, shows no trace whatever of muscular scars or imprints.

In that subdivision of the American Primordial known as the Lower Potsdam, and which is considered to lie above the *Paradoxides*-bearing strata of this continent, we have at Troy, N. Y., a species of *Lingulella* (*L. cœlata*), very closely resembling in the interior markings of its dorsal valve the dorsal valve of Linnarsson's *A. coriacea*, and in the same formation, both in New York and Canada, another form bearing an equally strong resemblance to his *A. granulata.* This latter American form is the *operculum of a Pteropod.* Its true character was first ascertained by Mr. Billings, who described it, together with the shell to which it belongs, in the Canadian Naturalist for December, 1871, under the name of *Hyolithellus micans.*† It is usually circular in

* "Om faunan i lagren med *Paradoxides ölandicus;*" af G. Linnarsson. (Afdrag ur Geologiska Föreningens i Stockholm Förhandlingar 1877, No. 40, Band III, No. 12).

† See also this Journal for May, 1872.

form, rarely broad-ovate longitudinally, and has an excentric apex or nucleus. Around this point the surface lines are arranged concentrically. Some of the specimens show also the existence of fine radiating lines in the nucleal region. The outer surface has usually a dullish aspect contrasting strongly with the inner one, which is polished and glistening. On the interior there are ten elongate-ovate muscular impressions having a stellate arrangement. The smaller of these occur on the dorsal side of the operculum. They all terminate in the pit directly beneath the nucleus. The shell and operculum are composed of a corneous substance, which has a finely lamellar structure. None of the specimens of the operculum have a perforation in the nucleus, but its extreme tip occasionally breaks away and gives it such an appearance. In this respect it recalls *Acrothele granulata*, in which the presence of an apical foramen does not appear to be a constant feature. The interior of *A. granulata* has not been observed and the dorsal valve is in doubt. The form is nearly circular, the deviation from this shape being transverse to that of the operculum of *H. micans.* The smallest specimen figured is 4 lines in width, and the largest about 5½ lines.

Associated with *Hyolithellus micans* we have at Troy three species of *Hyolithes*, and in the case of each the operculum has been identified and described. Two of these, *H. Americanus* and *H. impar*,* permit us to observe the interior of this piece. In neither do we find any trace of muscular scars. In this respect they recall the ventral valve of Linnarsson's *A. coriacea.* In all true *Hyolithes* the operculum appears to be invariably divided more or less distinctly into a dorsal and ventral limb. The majority if not all of the species have a calcareous shell, which in some cases is greatly thickened.† In *Hyolithellus*, on the other hand, the test is of extreme tenuity and corneous, and the division of the operculum into dorsal and ventral limbs only very obscurely indicated. Singularly enough, on the second plate accompanying his later paper referred to M. Linnarsson figures side by side an example of the ventral valve of his *A. granulata*, and the apical portion of a new species of *Hyolithes*, showing in its transverse section an outline corresponding almost exactly with that of the adjacent figure of *A. granulata.* Contrary to M. Linnarsson, the *Discina primæva* of Barrande and Verneuil,‡ if not a true *Discina*, appears to me much more probably an operculum than an *Acrothele*, as that genus is at present defined.

* The latter described by the writer in this Journal for June, 1872.

† M. Barrande, in his description of the Pteropoda of the Bohemian Basin, states that certain of his species of *Hyolithes* having a very thin test appear to make an approach to a corneous composition; but such a composition is not positively stated to characterize any of them (Système Silurienne, &c., iii, 1867, p. 66).

‡ Bull. Soc. Geol. Fr., t. xvii, p. 532, pl. VIII, fig. 2.

I do not intend by the foregoing observations to assert that the dorsal valve of M. Linnarsson's *A. coriacea* is the dorsal valve of a *Lingulella*, or that what he sets down as ventral valves of *A. coriacea* and *A. granulata* are both, or either of them, or any of the forms included under them, opercula of *Hyolithes* or Hyolithoid species, or to undertake to decide upon their nature or affinities in one way or another; but only to point out the manifest resemblances between the American and Swedish forms compared, and which appear to me to be sufficiently pronounced to at least suggest the question whether the Swedish species noticed may not, as a whole or in part, be susceptible of a more rigorous determination.

New York, January 22, 1878.

ART. LIII.—*On the "Geodes" of the Keokuk Formation, and the Genus Biopalla, with some Species;* by SAMUEL J. WALLACE, of Keokuk, Iowa.

THE large hollow stone balls, set inside with myriads of brilliant crystals, which are found in the upper beds of the Keokuk Formation (Subcarboniferous), are well known for their beauty and as curiosities, under the names of Geodes, Niggerheads, etc. They are very plentiful, of various sizes, from a few lines to over two feet, where that part of the formation is exposed in the Mississippi Valley, and in the lower Drift and the Alluvium derived from it.

This part of the Keokuk Formation, known as the Geode Bed, is exposed in a region about sixty by one hundred miles, with Keokuk, Iowa, as its center, where it is forty feet thick, covered by the St. Louis Formation. A few miles south it descends to the river level, from which it rises and disappears from the highest bluffs fifty miles north and south. About thirty miles east and west it disappears at the bottom of the deepest streams, under the Coal-measures of Illinois, and of Iowa and Missouri. It extends from the southeast corner of that space passing southeast and south beyond St. Louis; and it may extend also southwest through central Missouri. To the east it reappears along the eastern margin of the coal field through Indiana, probably into Kentucky, and as Professor Safford thinks, into central Tennessee. To the west it possibly reappears in the geodes found by Professor Comstock in the Wind River region, Government Survey.

The matrix bed is generally shale, varying sometimes to limestone and to porous rotten stone. The lower layers are limestone but not so pure as the next layer below, which here is the best quarry rock of the Keokuk Formation. Stratification marks often show over and around the geodes similar to those around bodies in mud banks formed by currents. The shale seems to be but the remains of original deposits several times thicker, which have evidently been dissolved out, leaving the insoluble portion to be compressed to the present shale. The limestone portions have not been compressed so much.

The geodes themselves are merely crystalline shells formed from percolating water around the walls of vacant cavities. The outer shell is silica, generally chalcedony, with crystals of various minerals, principally silica and calcite, pointed inward in great variety and beauty. The external forms are sharply marked as casts, as the shale is readily removed by frost and water, leaving the silica walls perfect and permanent. The shell walls are of all degrees of thickness, from perfectly solid to thin crusts, with sometimes no deposits at all in the still perfect cavity. Sometimes they are full and perfect in form, and in others they are more or less crushed, often quite flat. In those that are crushed the outer shell shows the fracture still sharp, but all held together by the inner portion deposited since the crushing. This crushing has been caused by the compression of the strata before referred to. But it shows that the dissolving out of part of the original deposit was after the partial deposit of the geode shell.

The origin of these cavities in the sedimentary deposit has been generally regarded as a mystery. That the shells were formed by crystallizing from water in the cavities is evident from their structure, which often shows fine bands of varied colors, etc., like agates; and by the fact that the cavities are sometimes still entirely vacant.

The Indiana Geological Report, 1873, page 278, gives the idea that they owe their origin to animal remains. This is plausible from the fact that they characterize a single formation and part of a formation, even, in the usual manner of fossils, (though I find cavities, in a certain bed of the St. Louis above, which I suspect had the same origin). It is rendered more evident by the peculiar family likeness through a great variety of sizes and forms; and by the lack of any other cause for them in such remarkable numbers, shapes and sizes.

An extended study of thousands of specimens and exposures, by the writer, confirms this by the recognition of peculiarities of growth and nature. It seems that the cavities were formed by *the rotting out of sponges* which had become covered by deposits. They were somewhat similar to the present horn sponges of trade, but without stems or apparent means of attachment. They may have often been movable, sometimes drifting along on the soft bottom, and often became covered in the soft deposits. They also often grew in fixed positions, as they are found crowded and fitting together in beds, with angular forms. It is evident that only those which became covered by deposits would leave any remains in the strata.

There is a great variety of forms and markings, but they are mainly of a few general and related types. The principal type is that of a massive peculiar cushion-like figure, with indrawn centers and connecting wrinkles, the intermediate spaces swelling lobe-like, more or less deeply marked, so as to resemble the features formed by holding stitches in stuffed cushions and upholstery. The indrawn centers probably represent the mouths of circulation-canals. There are some which do not show these peculiar markings, especially among the smaller ones, and in those which are crowded together in beds. But they were no doubt of the same nature. The several sides are similar, but the top is usually distinct from the lateral sides. They are frequently nearly round, sometimes higher than wide, but usually have three different diameters, the shortest of which is vertical, and so form a flattened oval.

There are indications that the structure was fibrous; the fibers mainly running conformable to the surface and to the wrinkled lines, toward some of the largest centers, at which they passed inward. Some have cup-like cavities of gash or almygdaloid form, some open, and others more or less closed. They have their longer diameters, one-third to one inch, conformable in direction to the supposed fibers and wrinkles.

The writer has a fine specimen which has grown over and around a projecting rock in an interesting way. Mr. L. A. Cox has one, five inches in both diameters, which has grown in a large crinoid stem. It has split the column in five parts, bending them apart to fit its form, into which they are imbedded up the sides. This is well preserved and curious.

Many fine as well as large specimens exist in collections here, and enough for many car-loads have been shipped away. The largest, showing the outside markings finely, is owned by R. F. Bower. It is twenty-six inches across. A larger one, twenty-eight inches, is in the Keokuk Library Collection.

The most promising field to look for details of structure is in the chert forming a large part of the Keokuk formation, which contains remains of various forms of life of those seas, often in better condition, as to details, than are elsewhere found.

Sponges which show internal structure are known from various formations. This generally arises from their being mineral sponges, or from their having been silicified before the original structure disappeared. In the Keokuk formation I know of nothing, outside of the chert, where a non-mineral body was silicified so as to show internal structure. All the non-mineral substance, and many parts formed of lime, have first entirely disappeared, so as to leave vacant cavities. Some of these are still vacant. But most have been afterward filled by crystals from water containing bicarbonate of lime and silica, which show no internal structure of the original body. This includes not only these grades, but a large proportion of the crinoids, shells and corals, that originally contained lime; so that this is not so strange for the non-mineral sponges as for those.

The following is the principal distinct type:

BIOPALLA (new genus).

Body, subglobular, varying in growth; size, usually a few inches, varying from one line to over two feet; no foot-stalk or apparent means of attachment; top, bottom, and lateral faces often distinct, but similar.

External markings, in large specimens, of two kinds of peculiar indrawn features: 1st. Indrawn centers, at unequal intervals over the surface (often one or more pit marks each), perhaps mouths of circulation-canals; 2d. Indrawn wrinkles, connecting, usually radiating from, one to another of the largest centers, in an irregular net work; and with smaller indrawn centers along the furrows. Surface, swelling lobe-like between the centers and furrows into a more or less deeply marked peculiar cushion-like figure.

Named from the Greek, *βίος*, life, and *παλλα*, a ball.

There is uncertainty as to the distinction of species, but I venture to name the following:

Biopalla Keokuk.—Typical species; size medium to large; form nearly rounded to flattened-ovoid; markings those of the genus, distinct, medium to numerous, varied in size and mode of distribution on same and different specimens.

From Keokuk, Iowa; Hamilton, Ill., and surrounding region.

Biopalla grandis.—Secondary type; size medium to largest; form ovoid horizontally; sides similar. Markings, those of the genus, very distinct, few to medium, symmetrical and regular. Interspaces large, swelling lobe-like. A few largest indrawn centers have peculiar radiating furrow marks, melon-like.

From Keokuk, Iowa; Clark County, Mo., and surrounding region.

Biopalla Wortheni.—Size medium to large; form varied; vertical and lateral faces different. Markings on top more or less sharp and crowded; on lateral sides, less numerous, and elongated vertically; on bottom not so sharp as on top; otherwise more or less varied, as in *B. Keokuk.*

From Hamilton, Ill.; Drift; and other places.

Biopalla Woodmani.—A peculiar form from the Drift, Keokuk, Iowa, supposed to be from the northward. Found as fragments; flattened by crushing before the crystalline deposit was completed. Interior often with brown, coarse, gritty clay from matrix, cohering by slight crystalline substance. Original form not known. Size medium to large. Markings, indrawn centers not distinctly defined, but indrawn lines distinct, forming a more or less intricate net work, with lines generally directed to the sides on top and bottom. The interspaces generally projecting prominently, as if a soft substance was forced through the meshes of a net, with some resemblance to a brain-like surface.

Biopalla Hæckeli.—Size medium to ——. Form sometimes flattened. Markings often distinct. Surface with more or less open gash-shaped cup-like cells, differing in size with the body, one-third to one inch in longest diameter, in directions conformable to those of the furrows.

A peculiar form. Keokuk, Iowa; Canton, Mo.; Drift, etc.

Biopalla Hyatti.—Size small to medium; form varied, generally elongated cylindrically. Markings distinct; on lateral or cylinder sides, centers usually on furrows that run crosswise or around the cylinder, often deep. Ends sometimes rounded; often flattened by contact.

From Keokuk, Iowa; Hamilton, Ill.; Drift, etc.

Biopalla Alicei.—Size small to medium. Form more or less flattened, lateral edges thin and centers more or less projecting. Markings generally not deep; often pit-like marks; sometimes an indrawn furrow runs diagonally from bottom to top or around, with centers along it. Often beautifully translucent, with peculiar markings.

From Drift, Keokuk, Iowa, etc.

Biopalla palmata.—Size medium to ——. Form flattened. Markings not deep on top and bottom, but elongated toward the edges; the edge deeply serrated by projecting interspaces, and deeply indrawn vertical furrows.

A rare and peculiar form. Keokuk, Iowa, Drift.

ART. LIV.—*The Coralline, or Niagara Limestone of the Appalachian System as represented at Nearpass's Cliff, Montague, New Jersey;* by Dr. S. T. BARRETT, Port Jervis, N. Y.

AT Mr. Wm. Nearpass's quarry, three miles southwest of Port Jervis, is a nearly perpendicular cliff over two hundred feet in height, which shows at top one hundred feet of exposed strata. The Stromatopora limestone, Favosite limestone of my former communication,* and the Tentaculite limestone with its two divisions of dark blue and quarry stone occupy the upper twenty feet of this cliff, while below the Tentaculite, and paleontologically connected with it, are nearly horizontal strata, about thirty feet in vertical thickness, apparently referable to the Water Lime division of the Lower Helderberg group. Lying below the Water Lime are fifty feet vertical thickness of exposed rock which contain species characteristic of the Coralline limestone at Schoharie, with a larger proportion of Niagara species than are reported from that locality, a few Clinton types and some perhaps new or peculiar species.

These species as far as identified are as follows:

Coralline limestone species: *Cyathophyllum inequale*=*Columnaria inæqualis*, *Strophodonta* —— =*Leptæna* —— of Plate 74, figs. 3*a* and 3*b*, Pal. N. Y., vol. ii, *Rhynchonella lamellata*=*Atrypa lamellata*, *Meristella nucleolata*=(*Atrypa*) *nucleolata*, *Calymene camerata;* all of which were identified by Mr. Whitfield; *Stromatopora constellata*, *Tellinomya* (?) *aequilatera* and *Avicula securiformis*, identified by myself.

Niagara species: *Halysites agglomeratus*, *Favosites pyriformis*, *Cladopora seriata*, *Cyatho Shumardi*, *Rhynchonella pisa;* identified by Mr. Whitfield; *Halysites catenulatus*, *Syringopora multicaulis*, *Favosites venustus*, *F. parasiticus*, *Stromatopora concentrica*, *Trematopora tuberculosa*, *Aulopora precius*, *Spirorbis inornatus*, *Pholodops ovalis* and *Ambonychia acutirostra*, identified by myself.

Clinton species: *Caninia bilateralis* by Mr. Whitfield, *Tentaculites minutus* and *Beyrichia lata* by myself.

A very beautiful *Proetus* of about the size and general outline, as far as can be conjectured from the fragments in my possession, of the *P. Stokesii* (?), Pal. N. Y., vol. ii, Pl. 67, occurs, very rarely, throughout this lower fifty feet. The pygidium is subsemicircular, narrowly rounded behind, margined. Lobes subequal, mesial lobe elevated, obtuse posteriorly, number of segments thirteen or fourteen, continued backward to the end. Surface of the cheeks and margin of the pygidium vermiculately striate, otherwise, as far as known, granulate. Inferior marginal portions of the pygidium and cephalic shield incrassated with imbricating lamellæ, appearing much as represented in fig. 4*a*, Pl. 66, vol. i, N. Y. Pal. This may be the same species doubtfully referred by Professor Hall to the *Proetus Stokesii* of Murchison, but differs very much from the figures and description there given. I have named it, provisionally, *Proetus pachydermatus*.

* This Journal, vol. xiii, pp. 385 and 386. The Stromatopora Limestone is best seen at Mr. Sandford Nearpass's Quarry, ⅛ mile northeast of Nearpass's Cliff.

The *Strophodonta** (*Leptæna*) —— of Pl. 74, figs. 3*a* and 3*b*, Pal. N. Y., vol. ii, is very abundant in the lower beds of this Coralline or Niagara limestone. Its ventral valve has the surface characters represented enlarged in fig. 3*b*,† its dorsal valve has the flat radiate striæ and the concentric, crowded, thread-like striæ represented in fig. 6*d* of the same plate. Both valves have a denticulated hinge line, the cast of the interior of the ventral valve resembles fig. 4*a*, the cast of the interior of the dorsal valve is near figs. 6*a* and 6*b* of the same plate. The impression of the cast of the interior of the dorsal valve shows widely divergent socket-ridges,‡ with three subparallel ridges in the bottom of the shell, the mesial longest and extending two-thirds the length of the valve toward the front. Old shells have about the size and form of fig. 4*a*. Shell flat, undulated, sometimes slightly resupinate, interior punctate. There are layers, I think from the lower unexposed part of the cliff, represented by bowlders at its foot, in which this shell is very closely packed. It, the *Rhynchonella lamellata*, *Proetus pachydermatus* and *Meristella nucleolata* originate in rocks of probable Clinton age and are continued upward into the Coralline. The *Cyathophyllum inequale* and most of those enumerated under the head of Niagara species are restricted to the upper half of this lower fifty feet. The total thickness of the Coralline limestone at this place cannot now be given, because its lower boundary is buried beneath the talus which covers the lower half of the cliff. The number of species belonging to the Coralline and Niagara limestones can be no doubt increased by further examinations, while the number of new species is probably no greater than has been found at other places where the Niagara has been examined. The, at least apparent, absence of many of the Coralline limestone species and the increase in the number of accepted Niagara species at this place agrees with the theory that the Coralline limestone is the thinned eastern edge of the Niagara deposits, which as it is traced southwestwardly along the Appalachians shows a fading out of Coralline and an increase of Niagara types.

Of the few Coralline limestone species, only the *Cyathophyllum inequale* and the *Strophodonta* (*Nearpassii?*) are abundant here, the other species being represented by a very few depauperate specimens only. The spherical and sub-pyramidal forms of Favosites are very abundant here as well as at Schoharie, and seem referable to species described by Professor Hall in the N. Y. Pal. for the Niagara group. The mural pores show plainly in thin vertical sections, or, better yet, in sections cut obliquely transverse to the axis of growth.

* I have labelled it provisionally *S. Nearpassii.*

† The postero-lateral radiate striæ are more arcuate.

‡ Cardinal processes not apparent.

ART. LV.—*Descriptions of new Genera and Species of Isopoda, from New England and Adjacent Regions;* by OSCAR HARGER. *Brief Contributions to Zoology from the Museum of Yale College,* No. XXXVIII.

THE genera and species described in the present paper are, except the first, marine and were, mostly, collected by the United States Fish Commission, along the New England coast. More complete descriptions with figures of all the new, and most of the old species, are nearly ready for publication in the Report of the Commissioner. As it seems desirable, however, to give a wider publication to the genera and species believed to be new, the following diagnoses are here inserted.

Actoniscus, gen. nov.*

Eyes small. Antennæ geniculate at the third and fifth segments; flagellum four-jointed. Terminal segment of maxillipeds lamelliform. Legs all alike. Pleon of six distinct segments. Basal segments of uropoda dilated and simulating the coxæ of the preceding segments; rami both styliform.

This genus belongs to the *Oniscidæ* and is near *Actæcia* Dana, MSS. (U. S. Expl. Exped., Crust., part II, p. 736, pl. 48, fig. 6), regarded as the young of *Scyphax*, but considered by Kinahan as the representative of a distinct family of the Oniscoidea.

A. ellipticus, n. sp. Body oval. Head with a prominent angular median lobe, and broadly rounded, divergent lateral lobes. Eyes oval, longitudinal, prominent, black. Antennulæ rudimentary. Antennæ nine-jointed; first segment short; second strongly clavate; third smaller, clavate; fourth flattened-cylindrical; fifth longest, slender, bent at the base; flagellum shorter than the fifth segment, composed of four subequal segments, tipped with setæ. Terminal segment of maxillipeds elongate triangular, ciliated and slightly lobed near the tip. First thoracic segment excavated in front for the head, shorter above than the following segments except the last, which is shortest. Legs small, scarcely spiny. Pleon continuing the regular oval outline of the thorax, apparently with four pairs of lamellar coxæ, the last pair are, however, the enlarged basal segments of the uropoda and are notched on their inner margins for the short outer rami, while the more slender inner rami are borne lower down on the under surface. The rami scarcely project beyond the general outline.

This species has been collected by Professor A. E. Verrill, at Savin Rock, near New Haven, and also at Stony Creek, in company with *Philoscia vittata* Say.

* From ἀκτή, the beach, and *Oniscus*.

*Chiridotea,** gen. nov.

First three pairs of legs terminated by prehensile hands, in each of which the carpus is short and triangular, the propodus is robust and the dactylus capable of complete flexion on the propodus. Antennæ with an articulated flagellum. Head dilated laterally. Operculum vaulted, with two apical plates.

This genus is founded on *Ch. cæca* (*Idotea cæca* Say), which occurs on this coast from Florida to Halifax, Nova Scotia. It includes *Ch. Tuftsii* (*Idotea Tuftsii* Stimpson), of the New England coast from Long Island Sound to the Bay of Fundy, and, as constituted above, would also include *Ch. entomon* (*Idotea entomon* Bosc.), from the Baltic and other European localities, and *Ch. Sabini* (*Idothea Sabini* Kröyer), from the Arctic. The above mentioned species ought certainly to be separated from *Idotea tricuspidata* Desm., which may properly be regarded as the type of the genus *Idotea* Fabr.

Synidotea,† gen. nov.

Antennæ with an articulated flagellum. Epimeral sutures not evident above. Pleon apparently composed of two segments, united above but separated at the sides by short incisions. Operculum with a single apical plate. Palpus of maxillipeds three-jointed.

This genus is founded on *S. nodulosa* (*Idothea nodulosa* Kröyer), who appears to have been misled, in his unnatural description of the epimera, by the marginal thickening of the segments. He describes the epimera as evident even on the first segment.

Astacilla Americana, sp. nov.

Body nearly uniform in size throughout in the female, with the fourth thoracic segment narrow in the male, tuberculated. Head united with the first thoracic segment, and, together with it, twice the length of the next two segments; excavated in front, with the sides extending beyond the middle of first antennular segment, tuberculated above, crossed between and behind the eyes by two transverse grooves, while a third groove indicates the suture of the first thoracic segment. Eyes lateral, round-ovate, broadest in front. Antennulæ four-jointed, slightly surpassing the second segment of the antennæ in the female, nearly attaining the middle of the third in the male; basal segment swollen, nearly as long as the next two which are much more slender, last or flagellar segment shorter than the peduncle in the female, longer than the peduncle in the male. Antennæ about three-fourths as long as the body, fourth segment longest, then the fifth and third; first two segments short; flagellum three-jointed, short. First thoracic

* From χέιρ, a hand, and Idotea. † From σύν, with or together, and Idotea.

segment embracing the head, separated from it by sutures at the sides, but united in the dorsal region. Fourth segment longer than the other six segments together in the female, still more elongated in the male, in which sex it is longer than the three following segments with the pleon, while in the female it is only four-fifths as long; irregularly but not coarsely tuberculated, especially in the dorsal region. Last three segments with their epimeral regions produced into salient angular tubercles. Pleon elongate-ovate, tuberculated, a little longer than the last three thoracic segments, with three transverse grooves in the proximal region, the second continued at the sides, but showing no distinct suture. Immediately behind this is a prominent tooth on each side, directed outward and backward. Tip of pleon not spiniform but only slightly attenuated and obtuse. Opercular plates more than nine-tenths as long as the inferior surface of the pleon.

Length of female 10mm., male 11mm.; diameter of fourth thoracic segment, female 1·2mm., male 0·52mm. Of the two adult specimens obtained, fortunately a pair, the male, though much the more slender, actually exceeds the female in length. This relation of size in the sexes is unusual in the genus, the females being generally considerably larger than the males, but more specimens are necessary to prove the constancy of this proportion.

The specimens of this species were found adhering to *Primnoa*, from St. George's Bank.

Astacilla Fleming, is synonymous with *Leacia* (*Leachia*) Johnston, which is preoccupied.

Eurycope robusta, sp. nov.

Body oval, smooth and polished, breadth nearly equal to half the length. Head longer than the first thoracic segment, produced medially into a short rostrum about half as long as the basal antennular segments. Antennulæ attaining the middle of the fourth antennal segment; basal segment subquadrate, bearing the second, much smaller, segment beyond the middle of its superior surface; third segment slender; flagellum about twice as long as the peduncle, multiarticulate. Antennæ thrice the length of the body at least in the female; first three segments short; fourth and fifth slender, subequal and together as long as the body in the female; flagellum long, slender and multiarticulate. External lamella of maxillipeds subrhombic, with the inner angle much rounded, the outer prominent but not acute. First four thoracic segments short; fourth widest, fifth and sixth suddenly twice as long; seventh much the longest of all. First pair of legs shorter than the body; carpus exceeding the propodus; second pair longer than the body; third and fourth increasing slightly in length; carpus and propodus subequal in all, armed, in the second pair only, with spines. Swimming legs (last three pairs) robust, carpus subcircular, dactylus usually about half as long as the propodus. Pleon broader than long. Uropoda short, rami cylindrical, spiny at the tip; the outer more slender but not shorter than the inner. Length of body 4·5mm. Carpus of first pair 1mm.; propodus 0·6mm.; of second pair, carpus 1·5mm., propodus 1·6mm.; of fourth pair, carpus 1·5mm., propodus 1·7mm. Color, in alcohol, pale honey-yellow.

This species was dredged in 220 fathoms, in the Gulf of St. Lawrence, by Mr. J. F. Whiteaves.

Ægathoa loliginea, sp. nov.

Body elongate oval, not suddenly narrower at the base of the pleon, which is slightly dilated at the last segment. Head subequally, but not deeply, lobed behind, the lateral lobes being formed by the large, semi-hexagonal, coarsely reticulated eyes, which cover half the upper surface of the head. Antennulæ as long as the head, eight-jointed, separated at their bases, tapering to the tip; antennæ more slender, ten-jointed, surpassing the antennulæ by the last two segments, like the antennulæ without evident division into peduncular and flagellar segments. First thoracic segment shorter than the head and but little broader, not embracing it at the sides, longer than the following segments, which increase in width to the fifth; seventh shortest. Epimera short and obtuse, not surpassing the rounded posterior angles of the segments. Legs nearly alike throughout, first pair a little more robust, last pair slightly the longest, all with strongly curved dactyli. Pleon longer than the thorax, tapering to the fifth segment. First pair of pleopoda with the basal segment large, nearly square; last pair, or uropoda, surpassing the telson; basal segment triangular with the inner angle acute but scarcely produced; rami flat, the outer with slightly divergent sides, obliquely rounded at the end; the inner broader, triangular, with the outer side longest; cilia very short almost rudimentary. Length 13mm., breadth 3·6mm. Color in alcohol yellowish with minute black specks, most abundant on the pleon. Eyes black.

The only specimen in the collection was obtained by Mr. S. F. Clark, at Savin Rock, near New Haven, from the mouth of a squid (*Loligo Pealii*), whence the specific name.

Ptilanthura, gen. nov.*

Antennulæ with the flagellum remarkably developed, multiarticulate, second and following segments provided with an incomplete, dense whorl of fine slender hairs. This whorl is interrupted in each segment upon its internal or anterior side,

* From πτιλόν a plume, and Anthura.

which, however, in the ordinary reflexed position becomes the external side. Eyes distinct, visible both above and below. Pleon imperfectly segmented, elongate. Maxillipeds two-jointed.

P. tenuis, sp. nov. Body smooth, slender, flattened above, broadest at the base of the pleon. Head broader but shorter than the first thoracic segment, narrowed to a point in front and less acutely behind. Eyes prominent, black, within the margin of the head. Antennulæ, when reflexed, attaining the third thoracic segment; first segment large but not longer than the second; third shorter than the second, followed by a short first flagellar segment, second and following segments about twenty in number, obconic, fitting into each other, flattened and naked on one side, which is the outer and somewhat inferior side in the reflexed organ, densely elongate-ciliate distally, except on the flattened side; cilia attaining about the fifth following segment. Antennæ hardly surpassing the peduncle of the antennulæ, eight-jointed. Maxillipeds with a quadrate basal segment, emarginate externally for the subtriangular external lamella, and bearing a single scarcely smaller terminal segment, truncate and ciliate at the tip. Thoracic segments slender, margined, the seventh but little over half as long as the others. First pair of legs moderately enlarged, segments well separated, dactylus strong, shorter than the inner margin of the propodus; remaining pairs of legs slender. Pleon about as long as the last three thoracic segments, first five segments consolidated along the median line, each rising into a low broad tubercle on each side of the median line; last segment as long as the preceding five; telson elongate-ovate obtusely pointed. Uropoda equaling the telson. Length 11mm., breadth 0·9mm., color in life brownish and somewhat mottled above, lighter below.

This species has been found on the New England coast from Noank Harbor, Conn., to Casco Bay, Maine.

Paratanais algicola, sp. nov.

Tanais filum Harger, Rep. U. S. Com. Fish and Fisheries, part 1, p. 573. 1874, *non* Stimpson.

Eyes conspicuous, black, plainly articulated, larger in the males. Antennulæ in the females three-jointed, tapering, setose at the tip, first segment as long as the last two which are subequal; elongated and eleven-jointed in the male, the first segment long, curved upward near the base, last eight segments with olfactory setæ. Antennæ short, five-jointed, deflected, fourth segment longest. First pair of legs robust, hand short and stout in the female, digital process scarcely toothed, bearing three setæ near its inner margin; hand in males strongly chelate, digital process elongated, curved, two-toothed; dactylus curved, slender, with about seven setiform spines on its inner margin; carpus in the males long and stout.

Second pair of legs elongated, basis flattened and curved, dactylus slender but shorter than the propodus. Bases of last three pairs of legs swollen. Uropoda bearing setæ at the tips of the segments, biramous; outer ramus short, scarcely if at all surpassing the basal segment of the inner ramus which is six-jointed and tapering. Length 2·2mm., breadth 0.33mm. Color nearly white.

This species is rather abundant among eelgrass and algæ at Noank and Woods-Holl, and probably other localities on the southern shore of New England. I formerly considered it as identical with *Tanais filum* Stimpson and supposed its range to extend as far as the Bay of Fundy. I now regard that as an error, as it is probable that *T. filum* is a true *Tanais* with simple uropoda, though I have as yet seen no specimens from the Bay of Fundy, nor any fully answering to Stimpson's description.

Paratanais limicola, sp. nov.

This species considerably resembles the preceding, but may be distinguished from it by the following characters: The eyes are small and rather inconspicuous, at least in the females, being only about half the vertical diameter of the antennulæ. The antennulæ have the second segment short, about half as long as the third. The dactylus of the second pair of legs, with its slender, acicular, terminal spine is longer than the propodus. The pleon is not dilated at the sides. The uropoda have the outer ramus two-jointed, slender, and surpassing the basal segment of the inner ramus which is five-jointed, with the basal segment long and imperfectly divided. Length 2·5mm.

This species was obtained on a soft muddy bottom in forty-eight fathoms, Massachusetts Bay, off Salem, in the summer of 1877, by the United States Fish Commission.

Paratanais cæca, sp. nov.

Body slender, elongated and loosely articulated. Head narrow in front, not broader than the bases of the antennulæ. Eyes wanting. Antennulæ four-jointed; first segment forming less than half its length; second segment longer than the third; last segment about as long as the second, slender, tapering and tipped with setæ. Antennæ attaining the tip of the third antennular segment. First pair of legs slender as compared with those of the preceding species, attaining the tip of the antennæ, basal segment subquadrate, hand or propodus less robust than the carpus; digital process of propodus serrated; dactylus short. Second (first free) thoracic segment two-thirds as long as the third, which is equal to the fourth and fifth; sixth and seventh progressively shorter. Second pair of legs scarcely more slender than the following pairs, basal segment not curving around the basal segments of the first pair. Pleon six-jointed; uropoda short, biramous, each ramus two-jointed, the outer more slender than the inner, half its length and bearing a long bristle at the tip. Length 2·5mm.

This species was taken along with *P. limicola* and unfortunately only a single specimen is as yet known.

Yale College, April, 1878.

ART. LVI.—*Ammonio-argentic Iodide;* by M. CAREY LEA.

WHEN silver iodide is exposed to ammonia gas it absorbs 3·6 per cent, and forms according to Rammelsberg a compound in which an atom of ammonia is united to two of AgI. Liquid ammonia instantly whitens AgI, every trace of the strong lemon-yellow color disappears. The behavior of the ammonia iodide under the influence of light differs singularly from that of the plain iodide, and will be here described.

The affinity of AgI for ammonia is very slight. If the white compound be thrown upon a filter and washed with water, the ammonia washes quickly out, the yellow color reappearing. If simply exposed to the air, the yellow color returns while the powder is yet moist, so that the ammonia is held back with less energy than the water. So long, however, as the ammonia is present, the properties of the iodide are entirely altered.

AgI precipitated with excess of KI does not darken by exposure to light even continued for months. But the same iodide exposed under liquid ammonia rapidly darkens to an intense violet-black, precisely similar to that of AgCl exposed to light, and not at all resembling the greenish-black of AgI exposed in presence of excess of silver nitrate. (This difference no doubt depends upon the yellow of the unchanged AgI mixing with the bluish-black of the changed, whereas in the case of the ammonia iodide the yellow color has been first destroyed.)

When the exposure is continued for some time, the intense violet-black color gradually lightens again, and finally quite disappears, the iodide recovers its original yellow color with perhaps a little more of a grayish shade. This is a new reaction and differs entirely from anything that has been hitherto observed. It has been long known that darkened AgI washed over with solution of KI and exposed to light, bleached. This last reaction is intelligible enough for KI in solution exposed to light, decomposes, and in presence of AgI darkened by light gives up iodine to the AgI and so bleaches it. The above experiment is quite different. The darkened substance may be washed well with water (during which operation it passes from violet-black to dark-brown), and may then be exposed to light either under liquid ammonia or under pure water, in either case the bleaching takes place, though in the latter case more slowly.

If the experiment be performed in a test-tube, the bleaching under ammonia requires several hours, under water from one to three days. But if the iodide be formed upon paper, and this paper be exposed to light, washing it constantly with liquid ammonia, the darkening followed by the bleaching requires little more than a minute. In this case, however, the bleaching is not so complete, perhaps because of the influence of the organic matter present. The bleaching appears to depend upon the escape of ammonia, for if the darkened ammonia iodide is covered with strong liquid ammonia and the test-tube well corked, the bleaching does not take place.

It became a matter of interest to know whether the darkening under ammonia was accompanied by any decomposition; whether the ammonia took up iodine from the silver salt under the action of light. For this purpose AgI was precipitated with excess of KI and subjected to a long and thorough washing; it was then exposed for several days to light under strong liquid ammonia. As AgI is not wholly insoluble in ammonia, the mother-water was first evaporated to dryness at a heat but little over ordinary temperatures. The traces of residue were washed with water, and this water gave distinct indications of iodine. The iodine present is in so small quantity that it may easily be overlooked, but it is certainly there. The washing given to the AgI was so thorough that it seemed impossible to admit that traces of KI remained attached to the AgI, but in order to leave no room for doubt, the experiment was repeated, using an excess of silver nitrate in making the precipitation, followed by thorough washing. Iodine was still found in combination with ammonia, and under these conditions there could be no doubt that AgI had been decomposed.

When AgI is blackened under ammonia in a test-tube, and the uncorked test-tube is set aside in the dark for a day or two, the AgI assumes a singular pinkish shade. It thus appears that AgI under the influence of ammonia and of light gives indications of most of the colors of the spectrum. Starting with white it passes under the influence of light to violet, and thence nearly to black: this violet-black substance washed with water passes to brown. The brown substance covered with ammonia and left to itself in an open test-tube becomes pinkish in the dark, yellow in sunlight. These curious relations to color which we see in the silver haloids, from time to time exhibiting themselves in new ways, seem to give hope of the eventual discovery of some complete method of heliochromy.

Philadelphia, March 25, 1878.

ART. LVII.—*Description of a Fossil Passerine Bird from the Insectbearing Shales of Colorado;* by J. A. ALLEN.*

THE species of fossil bird described in this paper is based on some beautifully preserved remains from the insect-bearing shales of Florissant, Colorado. They consist of the greater part of a skeleton, embracing all of the bones of the anterior and posterior extremities, excepting the femora. Unfortunately, the bill and the anterior portion of the head are wanting, but the outlines of the remainder of the head and of the neck are distinctly traceable. The bones are all *in situ*, and indicate beyond question a high ornithic type, probably referable to the Oscine division of the *Passeres*. The specimen bears also remarkably distinct impressions of the wings and tail, indicating not only the general form of these parts, but even the shafts and barbs of the feathers.

In size and in general proportions, the present species differs little from the Scarlet Tanager (*Pyranga rubra*) or the Cedarbird (*Ampelis cedrorum*). The bones of the wings, as well as the wings themselves, indicate a similar alar development, but the tarsi and feet are rather smaller and weaker; and hence in this point the agreement is better with the short-legged Pewees (genus *Contopus*). These features indicate arboreal habits and well-developed powers of flight. The absence of the bill renders it impossible to assign the species to any particular family, but the fossil on the whole gives the impression of Fringilline affinities.

Palæospiza bella, gen. et sp. nov.

Wings rather long, pointed. Tail (apparently)† about two-thirds the length of the wing, rounded or graduated, the outer feathers (as preserved) being much shorter than the inner. One side shows distinctly six rectrices. Tarsus short, its length a little less than that of the middle toe. Lateral toes subequal, scarcely shorter than the middle one. Hind toe about two-thirds as long as the middle toe. Feet and toes strictly those of a perching bird, and the proportionate length of the bones of the fore and hind limbs is the same as in ordinary arboreal *Passeres*, especially as represented by the *Tanagridæ*.

* From the Bulletin of the Geological and Geographical Survey of the Territories, vol. iv, No. 2, page 443, April, 1878.

† The character of the tail is given with reservation, since it is not quite certain that the whole of the tail, or that the exact form of the terminal portion, is shown, especially as the preserved impression is somewhat unsymmetrical.

1.

One of the specimens affords the following measurements:

	Inches.		Inches.
Humerus, length	0·80	Middle toe and claw	0·65
Forearm, length	0·95	Claw alone	0·20
Manus, length	1·02	Hind toe and claw	0·37
Coracoid, length	0·72	Claw alone	0·15
Clavicle, length	0·63	Wing	3·60
Tibia, length	1·00	Tail (approximate)	2·70
Tarsus, length	0·60	Total length (approximate)	6·85

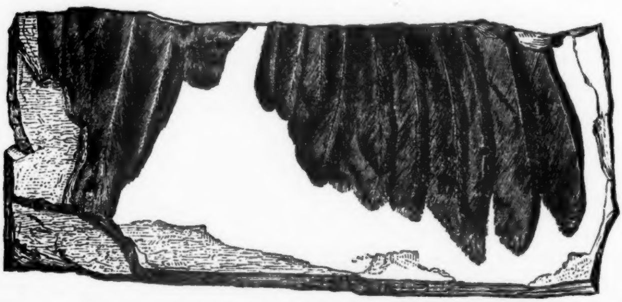
The bones still rest in the original matrix, and, being somewhat crushed and flattened, do not admit of detailed description and comparison with other types. The furculum is well preserved, and the limb-bones are all in place in their natural relation. The sternum is unrecognizable. The position of the cervical series of vertebræ and the general outline of the skull can be traced; but no structural characters of the head can be distinguished, except the proximal portion of the mandible. The long bones all present a well-marked longitudinal groove, due evidently to compression and fracture. This groove is distinctly traceable, even in such slender bones as tibiæ, tarsi, and clavicles. In point of size, while the furculum and the bones of the wing have all about the same length as the corresponding parts in *Ampelis cedrorum*, they apparently are considerably stouter. Their greater breadth may, however, be due simply to flattening from pressure. The tibiæ and tarsi are a little shorter than in the species last named, but the difference is only slight.

The most remarkable feature of the specimen is the definiteness of the feather impressions. Both the shafts and the barbs are shown with great distinctness in the rectrices, and the tips of the primaries of one wing are also sharply defined, overlying the edge of the partly expanded tail. The tip of the opposite wing can also be seen beneath the tail. The feet are so beautifully preserved that even the claws are perfectly distinct. (Fig. 1.)

Another specimen from the same locality, and probably representing the same species, consists of the tip of the tail and about the apical third of a half-expanded wing. (Fig. 2.) In this example the tail is also pointed and graduated. About seven of the outer primaries of the wing are shown with great distinctness, and two others can be easily made out. The third primary is the longest; the second is slightly shorter; the first and fourth are about equal. There are also in the collection three detached contour feathers of small size, but whether pertaining to the same species as the other specimens cannot, of course, be determined.

The larger specimen, first described, is divided into an upper and a lower half, the greater part, however, adhering to the lower slab. The bones adhere about equally to the two faces. The drawing is made from the lower slab, with some of the details filled in from the upper one. The feather impressions are about equally distinct on both, and where in either case the bones are absent, exact molds of them remain, so that the structure can be seen and measurements taken almost equally well from either slab, except that nothing anterior to the breast is shown on the upper slab.

2.



The species here described is of special interest as being the first fossil Passerine bird discovered in North America, although birds of this group have been known for many years from the Tertiary deposits of Europe. The highest extinct ornithic type hitherto known from America is a Picarian bird (*Uintornis lucaris*) related to the Woodpeckers, described by Professor O. C. Marsh in 1872, from the Lower Tertiary of Wyoming Territory. Probably the insect-bearing shales of Colorado will afford, on further exploration, other types of the higher groups of birds.

For the opportunity of describing these interesting specimens I am indebted to Mr. S. H. Scudder, who obtained them during his last season's (1877) explorations of the Florissant insect-beds. The specimens are now the property of the Boston Society of Natural History. My thanks are due to Mr. J. H. Blake for the great care with which he has executed the drawings.

In conclusion, I may add that in 1871 I obtained a few distinct impressions of feathers from beds of the same age and from near the same locality. The first fossil feather, to my knowledge, discovered in North America, was obtained by Dr. F. V. Hayden in 1869, from the fresh-water Tertiary deposits of Green River, Wyoming Territory. This was described by Professor O. C. Marsh in 1870,* who refers to it as "the distal portion of a large feather, with the shaft and vane in excellent preservation."

* This Journ., II, vol. xi, p. 272, 1870.

ART. LVIII.—*Experiment for Illustrating the Terrestrial Electrical Currents;* by Professor WM. LEROY BROUN.

THE following experiment enables a lecturer to exhibit to a large audience, in a very simple way, the action of the currents of electricity that pass around the earth. The experiment was suggested on reading an article by Professor J. W. Mallet, in the Philosophical Magazine for November, 1877.

A rectangular frame was made of light poplar wood, of section three by two centimeters, whose sides were in length a fraction over a meter, and in breadth three-fourths of a meter. About the perimeter of this rectangular frame were wrapped twenty coils of insulated copper wire: each extremity of the wire was made to terminate near the center of one of the shorter sides, and passing through the wooden frame was fastened and cut off about three centimeters from the frame. This rectangular frame was then so suspended, in a horizontal position, by wires attached to the frame of an ordinary hydrostatic balance, that the longer sides were at right angles with the beam. By adjusting weights in the pans the index of the balance was brought to the zero point. Two small orifices bored in a block of wood, a centimeter apart, served as mercury cups in which the extremities of the short terminal wires were immersed. Near the bottom and through the walls of these wooden cups were screwed small brass hooks, which served as connections, to which the wires of the battery were attached. The balance was now so placed that the longer sides of the suspended rectangle were at *right angles with the magnetic meridian* or in the *magnetic* east and west line.

When the current from the battery was made to pass around the rectangle from east to west on the northern side, and from west to east on the southern side, by the theory of terrestrial magnetism, the northern side of the rectangle would be attracted and the southern side repelled, and that this was so, the corresponding deflection of the balance rendered plainly visible. When the current was reversed the deflection was in the opposite direction. By breaking and closing the circuit at proper intervals to augment the oscillations, the large frame was readily made to oscillate through an arc of five degrees. When the sides of the rectangle were placed northeast and southwest the current produced no sensible effect. A bichromate of potash battery of sixteen cells with plates of zinc and carbon, twenty-five by six centimeters, was used.

With a rectangle containing a larger number of coils of wire, attached to a very delicate balance, by using a *constant acting* battery, the variation in the magnetism of the earth might thus be advantageously observed.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Specific Heat of Beryllium.*—Nilson and Pettersson of the University of Upsala have determined carefully the specific heat of beryllium, with a view to decide upon the position of this metal among the elements. It was prepared by decomposing the fused chloride with sodium in slight excess in an iron cylinder, heated to bright redness. On opening the apparatus after cooling, the upper portion contained a network of brilliant microscopic crystals of metallic beryllium, some of them appearing even to the naked eye distinctly prismatic, often aggregated in dendritic masses of the color and luster of steel. There were found also some fused globules of the metal, of which the largest had a diameter of two millimeters. Beryllium is permanent in the air, does not evolve hydrogen gas with water even on boiling, is easily soluble in dilute acids and in alkali hydrates, with active evolution of hydrogen, is not attacked, even at a red heat, by oxygen or sulphur, and burns readily in a current of chlorine forming the chloride. On analysis, the metal gave of beryllium 87·09 per cent; of beryllium oxide 9·84; of iron 2·08; and of silica 0·99=100·00. Its specific gravity at 9° C., was 1·9101; or, allowing for the impurities present, the specific gravity of pure beryllium is 1·64. The specific heat was determined in Bunsen's ice calorimeter, by Schuller and Wartha's modification. The specific heat of beryllium oxide was found, in a preliminary experiment, to be 0·2471 between 0° and 100° C. As the result of four experiments, the specific heat of pure beryllium was obtained as 0·4107, 0·4144, 0·4001 and 0·4064, giving as a mean the value 0·4079. As with this specific heat the atomic heat would be 3·75 only, if the atomic weight of beryllium be taken at 9·2, but would be 5·63 or normal, if the atomic weight be assumed as 13·8, it follows that beryllium belongs, not to the magnesium group, but to that of aluminum, that its atomic weight is 13·8, its specific heat 0·4079, and that beryllium oxide is Be_2O_3 as Berzelius claimed.—*Ber. Berl. Chem. Ges.*, xi, 381, March, 1878. G. F. B.

2. *On a new Synthesis of Olefines.*—Eltekoff has succeeded in effecting a new synthesis of hydrocarbons of the general formula C_nH_{2n}, by heating together for seven or eight hours molecular quantities of pentylene (prepared from commercial amylene), and methyl iodide to 210°–215° with an excess of anhydrous lead oxide. The product, freed from lead iodide and methyl oxide, which distilled completely between 36° and 85°, consisted to the extent of one third, of a mixture of C_6H_{12} and C_7H_{14}, boiling from 70° to 83°. This fraction combined energetically with bromine, yielding a solid compound fusing at 139°–140°, volatile with partial decomposition, and having the formula $C_6H_{12}Br_2$. Also with sulphuric acid, a liquid and a solid body separating out on dilu-

tion, the latter having a characteristic camphor-like odor, easily volatile in a current of steam, crystallizing from weak alcohol in long needles fusing at 75°–76° and having the formula $(C_7H_{16}O)_2.H_2O$. It is therefore pentamethylethol hydrate. Fuming hydrochloric acid also gave with this fraction a solid product recalling strongly camphor, boiling for the most part between 120° and 125°, and fusing at 100°. Analysis showed it to be a mixture of $C_6H_{13}Cl$ and $C_7H_{15}Cl$. Hence by the above reaction a hexylene and a heptylene are produced, the structure of which the author is engaged in investigating.—*Ber. Berl. Chem. Ges.*, xi, 412, March, 1878. G. F. B.

3. *Transformation of Olefine bromides into bromides of radicals of the Fatty Acids, by the simple addition of Oxygen.*—Demole, hoping by the direct addition of oxygen to the brominated olefines, to obtain mono, di, or tribrominated derivatives of an oxide of the olefine, made the experiment and observed that dibromethylene in presence of air changed readily into a solid substance. Repeating the experiment with pure oxygen, 50 grams of dibromethylene was placed in a 100 c.c. flask, the air displaced by dry oxygen, the flask closed with a rubber cork and strongly agitated for several minutes. The temperature rose and the cork was strongly pressed inward. This operation was repeated 30 or 40 times until the oxygen was no longer absorbed. The liquid, now at 55° C., was of a clear, yellow color, fumed in the air, was strongly acid, and contained a small quantity of the solid body. On fractioning, a product was obtained boiling at 147°–148°, possessing the formula and all the properties of bromacetyl bromide $(C_2H_2BrO)Br$. The reaction therefore is

$$\begin{matrix} CHBr \\ \| \\ CHBr \end{matrix} + O = \begin{matrix} CH_2Br \\ | \\ C{=}O \\ | \\ Br \end{matrix}$$

. On boiling the bromide with water, a crystallized acid was obtained, which was bromacetic acid. Tribrominated ethylene also absorbs oxygen under similar conditions, and yields dibromacetyl bromide.—*Bull. Soc. Ch.*, II, xxix, 204, March, 1878. G. F. B.

4. *On a Remarkable Reaction of Boric acid and Borax with the Polyatomic Alcohols.*—Klein has observed that when a mixture of a solution of borax and one of mannite is made in such proportions that less than half a molecule of borax acts on a molecule of mannite, the resulting liquid is acid. This reaction is not confined to mannite, but occurs also with glycerin, erythrite, levulose, dextrose, α and β galactose, so that a piece of litmus paper placed in the liquid takes a strong onion-red tint, and the mixture itself decomposes carbonates. Moreover, if one of the above named polyatomic alcohols in solution, be mixed with a solution of boric acid, so dilute that it no longer reddens litmus, there is at once developed a decided acid reaction, which turns litmus onion-red. The alkali-earthy borates behave in the same way as borax. In a subsequent paper, Klein gives the results of

his experiments to test the extreme delicacy of the boric acid reaction. If one cubic centimeter of a $\frac{1}{2000}$ solution of boric acid (just perceptibly acid to test paper) be mixed with 10 c. c. of a 15 per cent solution of mannite, a strong acid reaction is developed turning litmus paper onion-red at once. A $\frac{1}{10000}$ solution of borax, which is neutral, when 2 c. c. are mixed with 10 c. c. of the mannite solution, gives a bright-red at once. Five c. c. of a $\frac{1}{100000}$ solution added to 5 c. c. of the mannite solution, gave a decided acid reaction at the end of a minute. Quantitative experiments showed that the alkali required to neutralize the acidity thus produced, was the exact quantity needed to form the monometaborate.—*Bull. Soc. Ch.*, II, xxix, 195, 198, March, 1878.

G. F. B.

5. *On the Products of the Distillation of Resins and resin Acids with Zinc dust.*—CIAMICIAN has studied the products obtained by the distillation of common resin (colophony) and of its acid abietic acid, with zinc dust. The acid was prepared by Maly's method, and was obtained in white crystals. It was mixed, in portions of 20 grams with 10 grams of zinc dust, and distilled in a wide combustion tube in a current of hydrogen. From 600 grams abietic acid, 250 cubic centimeters of distillate were obtained, which on fractioning, gave toluene, metaethylmethyl-benzene, naphthalene, methyl-naphthalene, and methylanthracene. Colophony itself, when thus distilled gave the same products, and in about the same proportion with the exception of toluene, which was present in much smaller quantity. On distilling gum-benzoin with zinc dust, toluene, xylene, naphthalene, and methyl-naphthalene were obtained.—*Ber. Berl. Chem. Ges.*, xi, 269, Feb. 1878.

G. F. B.

6. *On the Triacid Phenols of Wood Tar and on the Synthesis of Cedriret.*—The lower fractions of wood tar having proved so interesting, HOFMANN has undertaken the examination of the fractions of higher boiling point, with especial reference to the beautiful body called cedriret by Reichenbach and cœrulignone by Liebermann. He has succeeded in proving the presence of a whole series of triacid phenols in this portion boiling between 240° and 290°, two of which he now describes. One of these, an oily body, having the formula $C_{11}H_{16}O_3$, forms a crystalline substance with alkalies, and boils at 285°. Treated with acetic oxide, it yields an acetyl derivative $C_{11}H_{15}(C_2H_3O)O_3$, which with bromine gives a bromo-compound $C_{11}H_{13}Br_2(C_2H_3O)O_3$. Heated to 130° with hydrochloric acid, torrents of methyl chloride are evolved, and a crystallized body is obtained having the formula $C_9H_{12}O_3$. This Hofmann regards as a higher homologue of pyrogallic acid, thus $C_9H_9\begin{cases}OH\\OH\\OH\end{cases}$; the methyl derivative $C_{11}H_{16}O_3$ being $C_9H_9\begin{cases}OCH_3\\OCH_3\\OH\end{cases}$ and its acetyl compound $C_9H_9\begin{cases}OCH_3\\OCH_3\\OC_2H_3O\end{cases}$. Since

in the latter body, bromine replaces two hydrogen atoms, the author believes the original body to be the dimethyl ether of a propylated trioxybenzene, or dimethyl propyl-pyrogallate. On oxidation it yields a quinone $C_8H_8O_4$ and this on reduction a hydroquinone $C_8H_{10}O_4$. The second substance obtained from the wood tar was isolated with difficulty and had the formula $C_8H_{10}O_3$. It formed splendid white prisms melting at 51°–52° and boiling at 253°. Concentrated hydrochloric acid heated with it in a closed tube decomposed it, evolving methyl chloride and affording a crystallized substance of the formula $C_6H_6O_3$, which was pyrogallic acid (pyrogallol). Hence the original substance was the dimethyl ether of pyrogallic acid $C_6H_3\left\{\begin{matrix}OCH_3\\OCH_3\\OH\end{matrix}\right.$. By the action of oxidizing agents, most conveniently potassium dichromate, it is converted into the magnificent steel-blue needles of cedriret. In proof of this as the origin of the cedriret of Reichenbach, Hofmann prepared this dimethyl ether synthetically and found that it gave identically the same product on oxidation.—*Ber. Berl. Chem. Ges.*, xi, 329, Feb. 1878. G. F. B.

7. *On the Constituents of Corallin.*—ZULKOWSKY has examined the corallin of commerce and finds it to be a mixture of at least six different bodies: 1st, a coarsely crystalline garnet-red body with blue luster, of the composition $C_{19}H_{14}O_3$; 2d, a derivative of this, in small violet needles, $C_{19}H_{16}O_6$; 3d, a green body crystallizing in needles with a metallic luster, $C_{20}H_{16}O_3$; 4th, the hydro-compound of this, $C_{20}H_{18}O_3$; 5th, a gummy amorphous body, colorless when pure; and 6th, the oxidation product of this, a deep red amorphous powder, showing metallic luster, resembling Baeyer's derivative from phthalidein and phenol.—*Ber. Berl. Chem. Ges.*, xi, 391, March, 1878. G. F. B.

8. *On Curarine.*—SACHS has examined the active substance of curare and finds it to be an alkaloid of the composition $NC_{36}H_{35}$ which he calls curarine. In the curare the alkaloid is combined with sulphuric acid as sulphate. The statements of Preyer he finds to be incorrect. Various reactions of the alkaloid are given in the original paper.—*Liebig's Ann.*, cxci, 254, Feb. 1878.

G. F. B.

8. *Protection of Marine Boilers.*—In marine steam engines with surface condensers, in which the water from the condensed steam is returned directly to the boiler, the boiler plates become rapidly corroded by the fat acids derived from the lubricators, and, moreover, the water condensed from the steam with the usual apparatus—even after filtering through animal black—is unfit for drinking and culinary uses. M. Hétet, chemist to the French marine, has removed these serious inconveniences by the use of lime-water, which he prepares as needed, and injects into the "feed pipe" in regulated quantities by very simple means. The lime soap which forms assumes a granular condition and falls to the bottom of the boiler, from which it is easily "blown out,"

while the water obtained from the steam is perfectly potable. M. Hétet gives evidence that his method has been thoroughly tried with entire success.—*Ann. de Chim. et de Phys.* (5), xiii, 29.

J. P. C., JR.

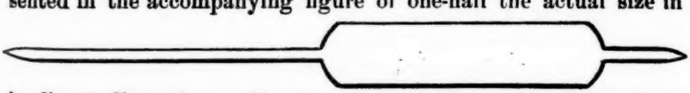
9. *Boracic Acid.*—M. ALFRED DITTE (Ann. de Chim. et Phys., (5), xiii, 67) has made some new determinations of the "heat of solution" of boric hydrate, and also of the "heat of hydration" of boric oxide, which have led to remarkable results. It appears from his experiments that one equivalent (62 grams) of boric hydrate in dissolving in 213 equivalents of water absorbs 3186·7 units of heat, and that one equivalent (35 grams) of boric oxide (fused boracic acid) in combining with water absorbs 6254·7 units of heat, taking as the value in each case the mean of several experiments. It is thus evident that although the heat of hydration is very large the heat absorbed by the hydrate in dissolving is likewise large, amounting to more than one-half of the previous quantity, and hence on dissolving the anhydride in the large mass of water required for its solution the elevation of temperature is not considerable. But if we add to the anhydride in fine powder only a small quantity of water—yet an excess over that required for its hydration—for example, double its own weight, and then stir the mixture, the powder immediately swells while absorbing water, and at the same time so much heat is evolved that the temperature of the mass rises to 100° C., and the excess of water is driven off as steam; the phenomena recalling those so familiar in the slacking of lime. From the specific heat of boric hydrate, M. Ditte calculates that with the exact amount of water required to form the hydrate, and assuming that none of the heat was dissipated, the temperature of the mass would be raised to 283°. M. Ditte finds that for the specific gravity of boric oxide at 12° the value $\delta=1·8476$, and at 80° the value $\delta=1·6988$. Hence we obtain for the coefficient of expansion between these limits the value $k=0·0013$. He also has determined the corresponding values for boric hydrate.

At 0°	$\delta=1·5463$	Between 12° and 60°	$k=0·00154$
12′	$\delta=1·5172$	" 12° and 80°	$k=0·00148$
14°	$\delta=1·5128$		
60°	$\delta=1·4165$		
80°	$\delta=1·3828$		

Further, it appears that the mean density of the boric oxide and ice, which may be regarded as united in the hydrate, is 1·3003, while that of boric hydrate at 0° is 1·5463. There must, therefore, be a considerable degree of condensation in the act of combination, which of course would be attended with evolution of heat. The amount of heat thus evolved is equivalent to that which would be required to expand the boric hydrate sufficiently to reduce its density to 1·300. This amount can readily be calculated from the coefficient of expansion and the specific heat already known, and it is found that the temperature required would be 136° and the amount of heat absorbed 2982·2 units. Evidently then less than one-half of the heat of hydration is due to this cause. M. Ditte has also determined the solubility of boric hydrate at various temperatures, and lastly, he has found the means of crystallizing the hydrate in hexagonal prisms of considerable size which have an easy basal cleavage. The crystals were obtained by the spontaneous evaporation of an aqueous solution acidulated with acetic acid and containing also in solution argentic nitrate. Analysis showed that these crystals were pure boric hydrate. J. P. C., JR.

10. *Boiling Point of Iodide of Antimony.*—In continuation of the writer's investigations on the Haloid Compounds of Antimony, the boiling point of antimonious iodide has been determined by Mr. W. Z. Bennett, student in the chemical laboratory of Harvard College. The observations were made with Regnault's air thermometer, but it was found possible to simplify very greatly the details of the process without seriously impairing the accuracy of the result. For temperatures above the range of a mercury thermometer, measurements accurate to one degree centigrade are all that the uncertain conditions of most problems permit, and all therefore that the circumstances demand. As used by Regnault, the air thermometer is capable of measuring such temperatures accurately to the one-tenth of a degree and by multiplying observations possibly to the one-hundredth of a degree. In his admirable investigation of the boiling point of sulphur at different temperatures, the observations of *temperature* are undoubtedly accurate to this extent, but Regnault's own discussion of these observations plainly indicates that there must have been unknown or accidental causes influencing his experiments, which render the results uncertain to at least one degree, and the boiling point of sulphur is still in doubt to this extent. It should be added, however, that there are only a very few boiling points which are known more accurately; for even when within the range of a mercury thermometer an observation of a boiling point to be accurate to a tenth of a centigrade degree requires an attention to circumstances which is seldom bestowed on such observations.

The glass thermometer bulb used in our experiments is represented in the accompanying figure of one-half the actual size in



its linear dimensions. The longer stem was made of fine thermometer tube, and a shorter stem was added to the opposite end of the bulb in order to facilitate the cleaning, drying, filling, or emptying of the interior—all of which was easily accomplished by the aid of a Bunsen pump. The shorter stem was of course sealed after the bulb had been dried and made ready for use, and before it was immersed in the medium whose temperature was to be measured. After an equilibrium had been established at this unknown temperature T°, the protruding end of the longer stem was sealed, and at the same time the height of the barometer H was noted. The bulb was then taken to a room of uniform temperature provided in the laboratory for gas analysis, and after being mounted on a convenient support, the end of the stem was broken off under mercury, and the apparatus left to itself for a time to secure a perfect equilibrium of temperature. This temperature (T'°) was then observed by means of a standard thermometer hanging near the bulb; also the height (h) to which the mercury had risen in the bulb was measured by a cathetometer, and in addition the height H′ of the barometer (hanging in the same room) was again noted. Closing now the open stem with the finger, the bulb was quickly inverted and the containing mercury drawn out into a tared vessel and weighed (nipping off the end of the shorter stem in order to admit the air). This gave the weight w. Lastly, the bulb and stems having been completely filled with mercury by suction, the weight (W) corresponding to their total capacity was obtained in a similar way. The required temperature could now be calculated by means of the following formula, which is easily deduced from the well-known law of Charles:

$$T^{\circ}+273^{\circ}{\cdot}2=(T'^{\circ}+273^{\circ}{\cdot}2)\frac{W}{W-w}\cdot\frac{H}{H'-h}[1+(T-T')^{\circ}k].$$

It will be noted that as the mercury columns, including the heights of the barometer, were all measured at the same constant temperature, and, as we are dealing with relative values only, no reductions are necessary. Moreover, an error of one-tenth of a millimeter in the value of $\frac{H}{H'-h}$ would make in determining the boiling point of sulphur (448°) a difference of only one-eighth of a degree, so that measurements of these heights are sufficiently close if accurate to one-half a millimeter, and might even be made with a common rule. The most uncertain element in the formula is the expansion of glass, but if the bulbs are made of flint glass (lead glass) tubing, such as is used for ornamental ware, the mean coefficient of expansion will vary very little from 0·000025 if the temperature does not exceed that at which the glass begins to soften. The rate of expansion of flint glass is not only less than that of crown, but it is also more constant and increases very slowly with the temperature. Flint glass is therefore the better adapted for the use we are describing. The expansion of the glass used in our experiments was carefully determined and found to have the value given above, within two or three tenths of a unit in the last place. A difference of one unit in this place would make a difference of one-third of a degree in the boiling point of sulphur.

In order to test the accuracy of the method, Mr. Bennett made four determinations of the boiling point of sulphur under different barometric conditions, which in the following table are compared with the results of Regnault reduced to the corresponding pressures:

Barometer. Height at 0°.	Boiling Point of Sulphur. Bennett.	Regnault.	Diff.
758·8	447°·4	447°·3	+1
763·9	448 ·2	447 ·7	+5
769·6	448 ·2	448 ·1	+1
776·7	448 ·2	448 ·7	−5
	Average difference,		·05

Regnault made eight observations on the maximum tension of sulphur vapor at temperatures varying from 387°·64 to 554°·03, and from a discussion of these deduced the constants of an exponential formula by which he calculated a table of maximum tensions for every ten degrees between the extreme limits, and also plotted a corresponding curve. It so happens, however, that the only two observations within the range of ordinary atmospheric pressure fall outside, and on the same side, of this assumed curve. These observations are the ones usually taken as indicating the boiling point of sulphur, and Victor Meyer in his method of determining the density of the vapors of substances, which have a high boiling point, assumes a value for the boiling point of sulphur (at the mean atmospheric pressure at Zurich) which he obtains by simple interpolation from the two observations just referred to.* In like manner we have calculated the above values corresponding to the presures at which Mr. Bennett's results were obtained on the basis of the same two observations; but instead of simply interpolating by first differences we have assumed that the variation between the two observed values would follow the law indicated by the general curve, which Regnault gives as the best expression for *all* his observations. But, according as we take the two observations, or the whole, we obtain values for the boiling point of sulphur differing by more than a degree, and hence, as we have already said, there is still an uncertainty in regard to the boiling point to this extent. As is evident, Mr. Bennett's observations confirm very closely the interpretation of Regnault's results adopted both by Victor Meyer and by ourselves, but since the boiling point of sulphur has become such an important constant we propose to have the observations repeated under the most favorable conditions we can command.

After the accuracy of our method had been thus placed beyond doubt within the limits required, Mr. Bennett made three determinations of the boiling point of antimonious iodide with the follow results:

Barometer. Height at 0°.	Boiling Point SbI_3.
758·1 millimeters.	400°·4
758·4 "	400°·9
759·3 "	401°·9

Probably only a small part of the differences between these observations depends on the variations of pressure, and 401° is the nearest whole number of degrees to the boiling point of antimonious iodide at the normal pressure of the air.

*This Journal, III, xiv, 484.

The method we have here described we can most confidently recommend as a most efficient and accurate means of determining high temperatures in chemical laboratories. It requires no expensive apparatus and no more delicate manipulation than most processes of gas analysis. Indeed, this method is most readily associated with Bunsen's methods for gas analysis, like those being most efficiently conducted in a room of constant temperature.

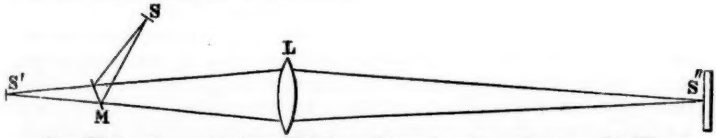
J. C. P., JR.

11. *The Influence of the density of a body upon its Light-absorbing power.*—Professor GLAN has conducted a series of experiments with chemically pure deuto-sulphate of copper, double chromate of potash, solution of iodine in absolute alcohol and solution of iodine in sulphuret of carbon upon the influence of density upon the absorption of light by these substances. He used a photometer, described in Wied. Ann., 1,351, 1877, with which by means of a double image prism, together with a Nichols prism, he could compare the absorption spectra. The author concludes from his experiments with the above mentioned substances that if there is any change of absorption with change of density that it must be very small. He is inclined to think that his results give evidence of this slight change. He also compared the absorption spectra of fluid bromine and bromine vapor and detected a decided change in the absorption coefficient.—*Ann. der Physic und Chemie*, No. 1, 1878, p. 54. J. T.

12. *On reflection of Polarized Light from the Equatorial surface of a Magnet.*—Dr. KERR details his optical experiments at full length upon the above subject. His previous results appeared to him to be confirmed. In the present paper he notices that the intensity of the optical effects of magnetization varies greatly with the angle of incidence. At an incidence of 85° the effects are very faint; between 75° and 60° they are comparatively clear and strong, and at 30° they grow fainter and similiar to the effects noticed at 85°. Dr. Kerr is inclined to believe that the effects are brought out better by reversals of magnetizing currents than by breaking it, in the case of steel. He deduces the following general laws: *First Law.*—The right-handed current conspires with a small right-handed rotation of the analyzer from extinction, and so forward. *Second Law.*—The right-handed current conspires with a small left-handed rotation of the polarizer from extinction, and so forward. These laws are subject to exceptions.—*Phil. Mag.*, March, 1878, p. 161. J. T.

13. *On a method of measuring the Velocity of Light;* by ALBERT A. MICHELSON, Ensign U. S. Navy, Instructor in Physics and Chemistry, U. S. Naval Academy. (From a letter to the Editors.)—The following method of measuring the velocity of light dispenses with Foucault's concave reflector, and permits the use of *any* distance. In the figure, S is a division of a scale ruled on glass; M, a revolving plane mirror; L, an achromatic lens; S″, a fixed plane mirror, at any distance from L.

The point S is so situated that its image S′ reflected in the mirror M, is in one focus of the lens L, while the image of S′ coincides with the mirror S″, which is placed at the conjugate focus. With this arrangement, when M turns slowly, the light from S″ is reflected back through the lens, so that an image is formed which coincides with S. When, however, the mirror rotates rapidly, the position of M will have changed while the light travels from M to S″ and back again, so that the image is displaced in the direction of rotation of the mirror.



Let V be the velocity of light; D, twice the distance M S″; *n*, the number of turns per second; *r*, the distance M S and δ the deflection; then V is found by the formula $V=\frac{4\pi rnD}{\delta}$.

In a preliminary experiment the deflection amounted to five millimeters when the mirror revolved 128 times per second.

II. Geology and Mineralogy.

1. *On the Limestones of the Falls of the Ohio*, by James Hall. 16 pp. 4to. Advance sheets of vol. v, part 2, of the Paleontology of New York.—Professor Hall reviews the facts with reference to the beds at the Falls of the Ohio and their fossils, gives the results of personal observations, and arrives at the conclusion that the rocks include—beginning below:

(1.) Niagara beds, of the Upper Silurian, which are the "Catenipora beds" of S. S. Lyon.

(2.) Upper Helderberg beds, to which belong the next following strata, (*a*) Coral beds, (*b*) Turbo bed, (*c*) Nucleocrinus bed, and (*d*) Spirifer bed, of Lyon.

(3.) Then 30 feet of Hamilton beds, which are of impure magnesian limestone, and comprise (*a*) the Hydraulic limestone, and (*b*) the Encrinital limestone, of Lyon.

(4.) The "Black Slate," which, after a special discussion of the facts, is made equivalent to the Genesee shale of New York.

Professor Hall remarks on the point that the Hamilton period is represented at the Falls only by limestones, mentioning the fact that the formation, which is 1,200 feet thick in the eastern part of New York State, and mainly arenaceous and shaly, with calcareous intercalations among the shales at its base, thins down, in 300 miles westward, to a few hundred feet of calcareous shales with some bands of limestone, and that farther west, the limestone gradually becomes still more predominant as the general thickness diminishes; adding that "it is therefore a fair and logical inference that the continuation of this group of strata farther west would preserve the calcareous beds alone."

2. *Report on the Fossil Plants of the Auriferous Gravel Deposits of the Sierra Nevada;* by L. LESQUEREUX. Memoirs of the Museum of Comparative Zoology at Harvard College. Vol. vi, No. 2. 58 pp. 4to, with ten double plates.—Professor Lesquereux here describes fifty species, and gives figures of the leaves on which they are based. He concludes:

(1.) The species are related by some identical or closely allied forms to the Miocene, and still more intimately by others to the present flora of the North American continent.

(2.) The North American facies is traced by some species to the Miocene, the Eocene, even the Cretaceous of the Western Territories. Hence it is not possible to persist in considering the essential types of the present North American flora as derived by migration from Europe or from Asia, either during the prevalence of the Miocene or after it. This flora is connatural and autochthonic.

(3.) The relation of the Pliocene plants of Nevada and Tuolumne Counties is with the flora of the Atlantic slope, and not with that of California at the present time. This fact is explained by the influence of glacial action during the prevalence of the ice-period, and is even clearly exposed by the distribution of the few Pliocene species remaining in the flora of the Pacific coast. The modification of the characters of the present flora of California have, therefore, to be looked for in climatic or other phenomena subsequent to the Glacial period. This remarkable fact, so clearly demonstrated by nature, may serve as an exemplification of the causes of the disconnection of some of the other groups of our geological floras.

3. *Memorandum of a fossil wood from the Keokuk formation, Keokuk, Iowa;* by SAMUEL J. WALLACE, of that place.—A portion of a supposed fossil wood was found in the Keokuk formation, Subcarboniferous, at Keokuk, Iowa, March 6th, 1878.

It was a section nearly three feet long; one end disappearing in the bluff, and the other having apparently been taken off in the quarry years ago. It is flattened into a layer resembling lignite, from $\frac{1}{16}$ to $\frac{1}{8}$ inch thick, and twelve inches across; divided into two portions with a space of about an inch between, and not quite on the same apparent plane. It does not seem to have external or bark markings, but rather those of woody fiber, possibly exogenous, which, however, has not been made out to any degree of certainty.

It was obtained in a quarry in the bluff beside the railroad track fronting the levee, nearly three blocks below Main street, from the best quarry layers of the Keokuk Formation, five feet below the "Geode bed," and from the center of a solid 18-inch limestone layer, on a horizon of numerous shells, fish teeth, etc. Is not this among the first distinct land plants from this formation?—*From a letter to the Editors.*

4. *Atlas accompanying the Report of the Geological Exploration of the Fortieth Parallel;* by CLARENCE KING, U. S. Geologist

in charge. Made by authority of the Hon. Secretary of War, under the direction of Brig. and Brevt. Major-General A. A. Humphreys, Chief of Engineers, U. S. A. 1876.—One of the maps of this Atlas has already been noticed in this Journal in volume xi (page 161). The completed atlas has recently been issued. It is in very large folio, and consists of ten double maps (nearly twenty maps of page size) illustrating the geology and topography of a region nearly fifty miles wide either side of the fortieth parallel from western Nevada to eastern Colorado. The atlas is a grand contribution to the Geology of the continent, and bears testimony to the very great care and thoroughness of the surveys under Mr. King. The five colored geological maps present not only the distribution of the several areas of igneous, granitic, and stratified rocks, but even of the principal kinds of igneous rocks—the rhyolites, trachytes, leucite rocks, porphyry, andesite, diorite and diabase, the study of which in the field, by Mr. King, has been supplemented by the exceedingly valuable volume of descriptions by Professor Zirkel, forming part of the Reports of the Survey.

The plates are from the establishment of J. Bien, New York, and are admirable specimens of chromo-lithography.

5. *Geological and Geographical Atlas of Colorado, and portions of adjacent Territories;* by F. V. HAYDEN, U. S. Geologist in charge, U. S. Geological and Geographical Survey of the Territories, Department of the Interior. Large folio.—This Colorado Atlas, just issued, is another very important contribution toward a general geological chart of the western half of the American Continent. It embraces twenty maps each of the size of two of the folio pages; a triangulation map from the work of J. T. Gardner of 1873, 1874, 1875, and subsequently of A. D. Wilson; a drainage map; an "economic" map giving the distribution of forests or groves of different kinds, pasture land, agricultural land, sage land, coal land, gold districts and silver districts; a general geological map; six sectional geological maps, and as many topographical, on a scale of four miles to the inch; two maps of geological sections and one of panoramic views. The areas of the various rock formations, including the subdivisions for the kinds of igneous rocks, are distinguished by colors. The map engraving and chromo-lithography are by J. Bien, as with the preceding atlas, and they show the same beautiful work in each respect, the harmony and choice of tints being all that could be desired.

6. *A Monograph on the Genera Zethus, Cybele, Encrinurus and Cryptonomus*, by A. W. VOGDES, U. S. Army. 36 pp. 8vo. Charleston, South Carolina.—This memoir is a historical and descriptive review of the genera, with descriptions of the species of Cryptonomus, illustrated by four plates, photographed from foreign memoirs, representing the following species: *C. punctatus*, *C. variolaris*, *C. bellatulus*, *C. obtusus*, *C. lævis*, *C. vigilans*, *C. sexcostatus*, *C. nereus*, and *C. verrucosus*. The limits of the genus are those accepted by Eichwald in 1840. It includes *Encrinurus*, and *Cybele* and *Atractopyge* are made subgenera under it.

7. *Carboniferous and Upper Silurian fossils of Illinois and Indiana.*—Dr. C. A. WHITE has published descriptions of some invertebrate species in the Proceedings of the Academy of Natural Sciences of Philadelphia for 1878, p. 29.

8. *Die Culm-Flora der Ostrauer und Waldenburger Schichten* von D. STUR. 366 pp. 4to.—An elaborate memoir on the fossil plants of the Lower Carboniferous formation of Moravia, illustrated by twenty-seven large and beautiful plates, a map, and two plates of sections. The lower Culm includes the Carboniferous limestone with *Productus giganteus* Sow., occurring in Altwasser, Neudorf near Silberberg, Hausdorf, etc., with which the "Culm-Dachschiefer," containing *Posidonomya Becheri* Br. is equivalent; and the upper Culm, the Ostrau and Waldenburg shales. Some of the specimens of plants figured are of remarkable size and interest.

9. *Remains of the Musk Ox* (*Ovibos moschatus*) have been found in the lœss of the Rhine near Unkel, according to F. Rœmer.—*Zts. geol. Ges.*, xxix, 592.

10. *Notice of three new Phosphates from Fairfield County, Connecticut;** by GEORGE J. BRUSH and EDWARD S. DANA.—(1). EOSPHORITE. Usually observed in prismatic crystals whose obtuse angle measures 104½°, and which probably belong to the orthorhombic system. The crystals are uniformly terminated by two pyramids in different vertical zones. Cleavage macrodiagonal nearly perfect. Also commonly compact massive. Hardness=5. Specific gravity =3·132–3·145. Luster vitreous to greasy. Color pink, some crystals having the bright shade common in rose-quartz, while others are paler and have a yellow to gray hue. The compact mineral is pale pink, greenish and bluish white and white. Some varieties closely resemble in color and luster green elæolite; the green color, however, is probably due in all cases to the presence of impurities. Transparent to translucent. Before the blowpipe in the forceps cracks open and fuses at about 4 to a black magnetic mass. Dissolves completely in the fluxes, and gives reactions for manganese and iron. Soluble in nitric and hydrochloric acids. Analyses by S. L. Penfield have proved it to be a hydrous phosphate of manganese, iron and aluminum, with the atomic ratio of $P_2O_5 : Al_2O_3 : RO : H_2O = 1 : 1 : 2 : 4$. This corresponds to the empirical formula $Al_2R_2P_2O_{10}, 4H_2O = AlP_2O_8 + 2H_2RO_2 + 2Aq$. The compact varieties contain quartz and other impurities. An analysis of a whitish compact specimen by Horace L. Wells gave 14·41 of insoluble impurities, and the remainder had the atomic ratio of eosphorite.

(2.) TRIPLOIDITE. Occurs in crystalline aggregates whose structure is parallel-fibrous to columnar, also divergent, and again confusedly fibrous to nearly compact massive. Isolated prismatic crystals are occasionally observed imbedded in quartz. In very rare cases these crystals have been detached with their terminations preserved; the crystallographic data thus obtained show that the mineral is closely related in form to wagnerite. Hard-

* Communicated by the Authors.

ness=4·5–5. Specific gravity=3·697. Luster vitreous to greasy-adamantine. Color yellowish to reddish brown, the crystals occasionally topaz- to wine-yellow. Transparent to translucent. Fuses in the naked lamp-flame, and B. B. in the forceps colors the flame pale green. Completely soluble in the fluxes, giving reactions for iron and manganese. Soluble in nitric and hydrochloric acid. Analyses by S. L. Penfield have proved it to be a hydrous phosphate of manganese and iron, giving the atomic ratio of $P_2O_5 : RO : H_2O$ of 1 : 4 : 1. This corresponds to the formula $R_4P_2O_9, H_2O=R_3P_2O_8+H_2RO_2$. The mineral in external character has a marked resemblance to triplite, and this fact is expressed in the name which has been given it.

(3.) Dickinsonite. Occurs foliated massive; often lamellar radiate, the laminæ being sometimes straight, but more often curved. In one instance observed in tabular crystals with striated base. These have a rhombohedral aspect, but are shown by an optical examination to be twins belonging to the orthorhombic (or monoclinic) system, the prismatic angle being about 120°. Cleavage basal, perfect; folia very brittle. Hardness =3.5–4. Specific gravity =3·338. Luster vitreous, on the cleavage face somewhat pearly. Color oil to olive-green, sometimes approaching grass-green. Transparent to translucent. In the closed tube blackens, fuses and gives off water having a faint acid reaction. Before the blowpipe in the forceps fuses at 1 to a black magnetic globule, and colors the flame pale-green with an occasional faint tinge of red. With the fluxes gives reactions for iron and manganese. Soluble in acids. The chemical analysis now in progress by S. L. Penfield indicates it to be a hydrous phosphate of iron and manganese with alkalies, the spectroscope showing the presence of both soda and lithia.

The above species are from a deposit of manganese minerals in a vein of coarse albitic granite which has been quarried for mica. Associated with them is a considerable amount of a ferriferous rhodochrosite which, according to Mr. Penfield's analysis, contains about 27 per cent of carbonate of iron. There are also present: a black phosphate of iron manganese and lithia, a purple phosphate resembling heterosite, and a black hydrated oxide of manganese; all these apparently are products of the oxidation of the other minerals. We have also determined the presence of vivianite, hebronite, apatite, and some other phosphates whose composition needs further investigation before a final conclusion in regard to their specific character. It is our intention to publish in the July number of this Journal a full description of the locality. This will include the results of the crystallographic and optical examination of the new species, the chemical analyses already made, with others still in progress, and all the facts in regard to the method of occurrence which we may obtain from the additional supply of material we expect soon to receive.

11. *Mineralogy: Vol. I, The General Principles of Mineralogy;* by J. H. Collins, F.G.S. 206 pp. 8vo. New York, 1878. (G. P.

Putnam's Sons—Putnam's Advanced Science Series).—This work is intended primarily "for practical working miners, quarrymen, field geologists, and students of the science classes." The first volume now issued (the second being in the press) contains a clear and systematic description of the physical and chemical properties of minerals. The system of Miller is principally used in the chapters upon crystallography, though the symbols of Naumann are also given. The value of this portion of the work is enhanced by the very large number of figures of crystals, which will do much to remove the inherent difficulties of the subject.

III. Botany and Zoology.

1. *Synoptical Flora of North America;* by Asa Gray.—The first part of this work is expected to be published before May-day. It will form a bound volume of itself, with index, etc.; but it is only the first part of vol. ii. The publication begins with vol. ii, because it takes up the American Flora where the Flora of North America by Torrey and Gray dropped it five and thirty years ago, viz: at the end of *Compositæ.* The ground which was covered by that work, newly worked over, will be comprised in the first volume of the new work. The present publication in cludes all the *Gamopetalæ* after *Compositæ*, and fills over 400 compact imperial 8vo pages. The price is fixed so as barely to recover the cost of the edition. For this sum ($6), it will be sent by mail to any part of the United States, post-paid, if ordered from the *Curator of Harvard University Herbarium, Cambridge, Mass.* In the trade it is published by Messrs. Ivison, Blakeman, Taylor & Co., New York.

2. *Bibliographical Index to North American Botany; or Citations of Authorities for all the Recorded Indigenous and Naturalized Species of the Flora of North America, with a Chronological Arrangement of the Synonymy;* by Sereno Watson. Part 1. Polypetalæ. Washington: Smithsonian Institution, March, 1878, 8vo, 476 pp. including table of Orders, and index to orders and genera.—This forms No. 258 of the *Smithsonian Miscellaneous Collections;* and surely it will be ranked among the most useful volumes of a valuable series. What a formidable undertaking it is, what a vast amount of pains-taking and critical labor has been bestowed upon it, may be imagined by turning over the well-filled pages, but will be adequately understood only by working botanists. To such it will be a great boon; and thankful will they be to the venerable Secretary of the Smithsonian Institution that he should have taken this work in hand, so rendering its production possible. Not less grateful should they be to the editor for his patience, conscientious thoroughness, and disinterested zeal, which, as in similar instances, can be recompensed only by the consciousness of having done useful work, very helpful to fellow-laborers and those who are to come after them. The Secretary, in his advertisement, states that this work "is published by the Smithsonian Institution, at the request of the leading bot-

anists of the United States, who have also contributed to the expense of its preparation." But the contributions must have been few and of comparatively small amount, while the labor has been protracted.

The portion now issued covers the ground of the first volume of Torrey and Gray's Flora of North America, i. e. of the Polypetalous Dicotyledons, and may therefore be regarded as a complete portion or volume. It is very elaborate bibliography, but not mere bibliography or index-making, for which simple painstaking might suffice; but it is a critical revision and re-investigation of the whole ground, not only supplementing that volume of the Flora by all that has been published since, but abounding in new and independent determinations and judgments. All the typographical arrangements and execution are excellent. To bring this volume well within the reach of all who need it, the price is fixed at two dollars, in paper covers. Those who need it most will much prefer bound copies. We may be useful by announcing that the editor has had a small number of copies put into strong cloth binding; and that these may be obtained, from the curator of the Harvard University Herbarium, at the additional cost, viz: at $2.25, if early application is made. A. G.

3. *On some points in the Morphology of Primulaceæ;* by M. T. Masters, M.D., F.R.S., etc.—A paper in the first volume of the new series of the Transactions of the Linnean Society of London (in which Botany and Zoology are separate), based upon a review of the principal monstrosities known in Primroses, and in other plants, so far as they throw light upon these; illustrated by three plates, crowded with figures; followed by a full selection of the bibliography of the subject. The placenta of *Primulaceæ* is concluded to be "a direct prolongation of the receptacle or axis, without any connection with the sides or apex of the carpels." "Yet in some monstrous flowers, placentæ are outgrowths either from the margin or center of carpels; these outgrowths may become detached, and may cohere with one another, thus producing the appearance of a solid column directly produced from the receptacle. Such forms of placenta lead to the inference that the ancestral progenitors of *Primulaceæ*, had parietal placentation." It may be added that the whole does not militate more against present carpellary placentation in *Primula* than in *Dionæa.* The ovular integuments are concluded to be foliar. The explanation of the anteposition of stamens to corolla-lobes and of the later appearance of the corolla is not at all settled. A. G.

4. *On the Origin of Floral Æstivations, etc.;* by Rev. G. Henslow, M.A., F.L.S.—A paper in the same volume of Linn. Trans. The forms of æstivation are classified under eight equivalent kinds, five of which we should regard as species or varieties of the imbricative; the term *convolute* (in place of contorted) is heartily adopted for one of them, following the suggestion in this Journal; the degrees of frequency of the various kinds are indicated; the mode in which they may pass into each other is shown; their origination under evolution speculated upon with

ingenuity; the cruciferous flower is conceived to have arisen by symmetrical reduction of fives to fours, etc.; the hypothesis that the corolla of *Primula* is an outgrowth of the andrœcium is controverted, more particularly on the ground that the development of the parts of normal flowers is by no means always centripetal. A. G.

5. *Floral Structure and Affinities of Sapotaceæ;* by MARCUS M. HARTOG, M.A., etc.—A short paper in Trimen's Journal of Botany, for March, 1878. Observations made at the Botanic Garden at Peradeniya, Ceylon, and very neatly worked out. As to the ovules, "the impression" is that they are the axillary buds of the carpels. Flowers almost always proterogynous. Evolution in the flower "strictly centripetal, with a tendency to augmentation in the number of parts in the whole as we advance from the periphery inwards." "Each new member arises in front of the widest intervals between the next oldest members. If the intervals be wide, the new members are formed in front of the widest intervals between the members of the next oldest whorl and those of the next but one," both falling under Hofmeister's generalizations. The order nearest to *Sapotaceæ* is *Myrsinaceæ;* and *Styracaceæ* (*Symploceæ* being separated) nearer than *Ebenaceæ*. Finally the "outgrowth" theory of the petals of *Primulaceæ* is opposed by the inference that the origin and structure of the corolla must be essentially the same in this order as in *Myrsinaceæ;* that "in many plants the petals, though first formed, are soon overtaken and outstripped by the stamens. Carry the delay a stage further back, and you have the history of *Primulaceæ*." The paper closes with an amended character of *Labourdonnaisia*, and of an allied new genus *Eichleria*, in honor of one of the best morphological botanists of the day, Dr. Eichler, who —let us add our congratulations—succeeds to the chair vacated by the death of Alexander Braun at Berlin. Professor Schwendener, from Tübingen, takes the new chair of Physiological Botany at Berlin. A. G.

6. CURTISS: *North American Plants.*—The first part of the collection of dried plants of our Southern States (250 species), which Mr. A. H. Curtiss announced a year or more ago, is now issued. The set supplied to the Harvard University Herbarium enables us to declare that the specimens are well chosen, copious and perfect, are carefully put up, all named, with printed tickets in neat form and taste; and that these sets are cheap at the price, viz: twenty dollars for 250 species. To favor this laudable enterprise and to facilitate their acquisition by botanists, some sets have been deposited at the Harvard University Herbarium, the Curator of which will receive applications for them. A. G.

7. *On the Spore-Formation of the Mesocarpeæ, and especially of the new Genus Gonatonema;* by Dr. V. B. WITTROCK.—In the genus *Gonatonema*, founded on *G. ventricosum*, a new species, and the old *Mesocarpus notabilis* of Hassall, the cells bend into something like a knee-joint, and divide into three parts, in the central one of which the spore is formed directly, without conju-

gation. Dr. Wittrock observed a rotation of the chlorophyll-bands previous to the formation of the spore. The writer calls attention to the fact that in *Mougeotia calcarea* he has found that the spores are sometimes formed in three different ways, supposed to be characteristic of the three different genera, *Mesocarpus*, *Plagiospermum* and *Staurospermum*. W. G. F.

8. *Non-Sexual Outgrowths on Fern Prothalli.*—The discovery of the non-sexual production of the Fern-plant from the prothallus, by Dr. Farlow, when a pupil of De Bary at Strasburg, has been extended to numerous instances. The facts and bearings of the case were reported to the Society of German Naturalists, at the late meeting at Munich, by Professor De Bary, as follows: "Investigation has shown that some Ferns, namely, *Pteris Cretica*, *Aspidium falcatum*, and *Aspidium Filix-mas*, var. *cristatum*, form on the prothalli normal antheridia but generally no archegonia, or imperfect ones which perish before the opening of the canal, and exhibit instead of the typical formation of the embryo, the outgrowth described by Farlow. In those species which develop archegonia no such outgrowth has been observed. The morphological phenomena presented by the shoot are alike in the species named, even in the smallest particulars. In the prothallus which grows directly out of the spore, the development which occurs in most cases, and which may be called normal, is as follows: at the sinus, nearly at the spot where the first archegonium occurs, there arises a protuberance which grows out directly into a leaf, at the base of this, close by the insertion of the prothallus, there is formed an axial *punctum vegetationis*, on which a second and the successive later leaves appear. At the base of the first leaf there is formed, endogenously on the vascular bundle, the first root. As soon as the second leaf appears, the bud grows like an ordinary fern-shoot. Variations differing in degree from the normal mode of growth are not uncommon. Frequently the prothalli form branches similar to themselves (secondary prothalli) which can again produce leaves and shoots in a great variety of forms. A moment's reflection shows that the three Ferns in question have lost the power of forming archegonia, and with it sexual reproduction, and as compensation for the sexual formation of the embryo, possess the power of forming the outgrowth described by Farlow. This presents a special case of that general phenomenon which is called *apogamy*, total loss of reproductive power, and which consists in the fact that a species loses sexual reproduction and receives in its place numerous non-sexual modes of propagation, such as brood-buds, suckers, etc. The numerous bulblets of the higher phanerogams, species of *Allium*, *Dentaria*, and the like, are examples of this, as well as of the successive degrees of difference in apogamy." Closer observation of the phenomena of reproduction in apogamous plants other than Ferns was recommended. Dr. Farlow's paper was originally published in the Proceedings of the American Academy of Arts and Sciences, vol. ix. G. L. G.

9. *A Catalogue of the Flowering Plants and higher Cryptogams growing without cultivation within thirty miles of Yale College.* Published by the Berzelius Society, New Haven, 1878, pp. 72, 8vo, and an outline map.—This catalogue has reached us barely in time for announcement here. Its form and typography are attractive, and the editors (whose names are not mentioned), appear to have done their work admirably, under the auspices of Professor Eaton, who adds an introduction, with interesting historical details. The catalogue extends to the *Musci* and *Hepaticæ*, and the summary of species gives the total number of 1,506.

A. G.

IV. Astronomy.

1. *Der Sternhaufen χ Persei*, etc., von Dr. H. C. Vogel. Leipzig, 1878. 4to, pp. 36.—Dr. Vogel, of the Potsdam Observatory, has published the results of measures of the cluster χ *Persei*, made in 1867–70 by means of the 8-inch refractor at Leipzig, with the object of fixing the relative positions (and magnitudes) of the stars of this cluster, so that any future change may not pass undetected. 176 stars, in all, have been fixed in position by the filar-micrometer. The field was bright, and a magnifying power of 145 diameters was employed throughout. The various sections of this work of 36 quarto pages treat of the following subjects:

§ 1. *The position of the instrument; the determination of the parallel.* A novel feature here is that the zero of position was determined before and after each set of measures (either of p and s or of $\Delta\alpha$ and $\Delta\delta$) on each pair of stars, so that the observations for any pair are arranged thus: 1st, four measures of p; four measures of s; 2d, determination of parallel; the next pair is then observed as follows: 1st, four measures of p; four measures of s; 2d, determination of parallel; and so on throughout the night.

§ 2 contains an *investigation of the position-circle;* and of the *value of the revolution of the micrometer.* The zero of the micrometer was found to be dependent upon the position of the instrument and also upon the kind of illumination of the threads. The value of the revolution is found from transits on 20 nights, from Nov., 1867, to May, 1870. During all this time the reticle was left at the same distance from the objective, and the thermometric coefficient resulted $+0''\cdot001581\ t^{\circ}$ in Reaumer's scale. The magnitude and the *sign* of this, Dr. Vogel explains by the fact that the focal point was not determined each night (as he says is usual), and he correctly points out the necessity of leaving the focus unchanged for such observations and for determining the value of the screw during the series itself.

§ 3 deals with *the methods of observation and reduction.* The brighter stars less than 10th magnitude were determined from measures of p and s with four selected stars of the group. These four were connected by measures of p and s and also $\Delta\alpha$ and $\Delta\delta$; and they were further connected with two stars of the cluster *h Persei*, which had been observed with the Bonn meridian-circle. The pairs of stars were observed alternately on different threads, the zeros determined under the same circumstances as those of the observations, the position angles measured by turning the circle in both ways. From four to six measures of p and s were made each night, and for each pair of the brighter stars at least four nights observations were made, i. e., at least sixteen measures of p and s. The reductions are complete, and the observations are reduced to 1870·0.

The fainter stars (10–12 mag.) were observed by $\Delta\alpha$ and $\Delta\delta$ with other stars at least on two nights for each star.

§ 4 deals with the *accuracy of the observations;* for the brighter stars, the probable error of a *single observation* is found to be, in s, $\pm 0''{\cdot}228$, in p (reduced) $\pm 0''{\cdot}306$. The probable errors for the *mean of each night* are more important, and result as follows (no dependence of the probable errors on the distance or the position-angles being evident), probable error of one night in s, $\pm 0''{\cdot}190$, in p (reduced) $\pm 0''{\cdot}165$. For the final position (at least four nights) these become, in s, $\pm 0''{\cdot}092$, in p, $\pm 0''{\cdot}080$. For the $\Delta\alpha$ and $\Delta\delta$ of the brighter stars these are $\pm 0''{\cdot}097$ in R.A. $\pm''{\cdot}089$ in N.P.D. The positions for the fainter stars are determined within less than $1''$ in each coördinate, which Dr. Vogel considers sufficient for his purpose.

§ 5 treats of the *determinations of the brightness of the stars of this cluster.* The 176 stars of the cluster range between the 6·5 and 13th magnitudes.

Each one of the fainter stars (higher than 10 mag.) was determined by eye estimates of magnitude at least 5 times; the probable error of the mean is $\pm 0{\cdot}14$ magnitude. The brighter stars were determined on several evenings by the eye, and on two nights each was compared by a Zollner's photometer with one of the standard stars. A table (p. 12) gives the magnitudes of the brighter stars, 1st, by eye (Vogel); 2d, by eye, (Argelander); 3d, photometric magnitude, assuming the light ratio $\frac{1}{2{\cdot}512}$ or 0·397. The agreement is remarkable, but the table shows (what was already known) that Argelander's magnitudes higher than $9{\cdot}0^m$ make the stars too bright.

§ 6 gives the *Observations of the stars* (in tabular form) *and the Results.* A difference between the Spring and Autumn observations, in *both* $\Delta\alpha$ and $\Delta\delta$, of one of the stars indicates possibly a parallax of about $0''{\cdot}3$.

§ 7 gives the *Observations of the Fundamental Stars; and Catalogue of the* 30 *brightest stars.* The observations are of relative $\Delta\alpha$ and $\Delta\delta$ of the four fundamental stars, and of two of Argelander's stars in *h Persei* and also meridian observations. These last also indicate a parallax to the star *b*. None of the stars appear to have a large proper motion.

§ 8 deals in the same way with *Observations of the fainter stars; and Catalogue of all the stars of the cluster.* This is followed by two charts, one of the brighter stars and the plan of triangulation, the other of the whole cluster.

This brief analysis will give an idea of the contents of this extremely thorough paper, which will take its place beside the other researches of the author in the same field. They are all models of what such investigations should be, and leave nothing to be desired in methods of observation or reduction, in the accuracy of the final results reached (which are always adequate to the purpose in hand), and, finally, are excellent examples of the literary style and clearness appropriate to such memoirs.

E. S. H.

2. *American Journal of Mathematics Pure and Applied.* Published under the auspices of the Johns Hopkins University. Vol. i, No. 1. 4°, 104 pp. Baltimore, 1878.—We are glad to greet the first number of this quarterly. It fills a place in American Journals that has been too long vacant. The primary object of the Journal is to publish original investigation. In addition, concise abstracts of subjects to which special interest may attach, and critical and bibliographical notices and reviews of the most important mathematical publications form part of the plan.

The present number contains contributions from Messrs. Newcomb, Hill, Eddy, Weichold, Cayley, Rowland, Peirce, Sylvester. The two longest articles are by Mr. G. W. Hill, *Researches in the Lunar Theory*, and Professor Sylvester, *On an application of the new Atomic Theory to the graphical representation of the Invariants and Covariants of Binary Quantics.*

3. *Publications of the Cincinnati Observatory.*—No. 4 of this series contains a table of micrometric measurements of Southern Double Stars, covering 72 pp. royal octavo, made during the year 1877 by Messrs. Herbert A. Howe and Winslow Upton, and the Director of the Observatory, Prof. Ormond Stone.

V. Miscellaneous Scientific Intelligence.

1. *Driftless Region of Wisconsin.* (Communication to the Editors.)—There are one or two sentences in Professor Dana's paper on the "Driftless Interior of North America," in the April number of the Journal, which call for remark from me, since their effect is to credit me with more than I deserve in the matter of the theoretical conclusions as to the glacial phenomena of the northwest, given in volume ii of the Geology of Wisconsin. As the same error occurs in other reviews of our work, it is evident the matter is not made as plain as it should be in the reports themselves. I give, therefore, a brief statement of the facts. In 1874, Professor T. C. Chamberlin investigated the already known Potash Kettle Range of Eastern Wisconsin, and came to the conclusion that it was a gigantic moraine produced by the separate glaciers of the Green Bay and Lake Michigan troughs. Subsequently he traced the range much farther southward than before known, found it curving westward and northward again, and carried it to the southern boundary of the district under my charge. In June, 1875, he furnished me with a map

on which he had marked the probable position of the continuation in the Central Wisconsin District. Afterward I verified this and located the range as mapped in my report; and in studying out my own observations on the Glacial Drift, found them to harmonize so thoroughly with his theory that the Kettle Ranges are continuous moraines, that I yielded to his idea and used it in explaining the phenomena observed in my own district—among them the existence of the Driftless Region. The honor of the first recognition of these great moraines as such, and of their great value as indicators of the positions and size of the various glaciers, and of glacial movements generally, must be given entirely to Professor Chamberlin. Should this idea stand the test of investigation, it will, beyond doubt, lead to some important conclusions.

ROLAND D. IRVING.

2. *A Treatise on Chemistry;* by H. E. ROSCOE, F.R.S. and C. SCHORLEMMER, F.R.S., Professors of Chemistry in Owens College. Vol. I. The Non-metallic Elements. 769 pp. 8vo. New York: 1878. (D. Appleton & Company).—This treatise supplies a want which every teacher and student of chemistry feels; of a clear succinct statement of the facts of modern chemistry, fairly complete and with such a discussion of chemical theory as the present state of the science permits within the proper scope of such a work.

3. *Report of the Superintendent of the Coast Survey for* 1874. —This volume contains, among its very valuable articles, the elaborate paper in full of Mr. Charles A. Schott (Assistant in the Coast Survey) on the Secular change of Magnetic Declination in the United States and other parts of the United States, and also another by J. E. Hilgard, Assistant, on the determinations of Transatlantic Longitudes of 1872, being the final Report, giving a review of previous determinations.

4. *Minnesota Academy of Natural Sciences.*—The Bulletin for 1877 contains a catalogue, with notes, of the Mycological flora of Minnesota, by A. E. Johnson, M.D., occupying 100 pages.

5. *Matter and Motion;* by J. CLERK MAXWELL, M.A., LL.D., etc. 224 pp. 12mo. New York, 1878. (D. Van Nostrand—Van Nostrand Science Series.) This essay is reprinted from the April and May numbers of Van Nostrand's Magazine. It is a very clear statement of some of the fundamental principles of physics by a most eminent authority.

6. *Contributions to North American Ethnology: Tribes of California;* by STEPHEN POWERS. Department of the Interior, U. S. Geographical and Geological Survey of the Rocky Mountain Region, J. W. Powell in charge. 636 pp. 4to, with a map and several 4to plates.—The work treats with fullness of the people and all their characteristics, and the plates illustrate their forms, features, music, habits, weapons, implements, etc. Many of the pages of the volume are occupied by vocabularies from various sources, edited by Prof. Powell.

Report of the Chief of Engineers for the year 1877. Parts I and II. 1456 pages, 8vo. 1878.

OBITUARY.

DR. CHARLES PICKERING.—Dr. Pickering died in Boston on the 17th of March, of pneumonia, at the age of seventy-three. He was a grandson of Col. Timothy Pickering, who was a member of Washington's cabinet and one of the most distinguished men of his day. He was a member of the class of 1823 at Harvard College, and graduated from the Massachusetts Medical School in 1826. He practiced medicine several years in Philadelphia, and while there devoted much of his time to the Academy of Natural Sciences of that city.

In 1838, Dr. Pickering was appointed one of the Naturalists of the United States Exploring Expedition under the command of Charles Wilkes, U. S. N. The expedition gave him good opportunities for pursuing his favorite studies. And these opportunities for original observation were further enlarged; for, soon after his return from this voyage, on the 11th of October, 1843, he left for Egypt, Arabia, India, and the eastern part of Africa, in order to continue his investigations with regard to the races of men and the distribution of plants and animals. Again at home, he published, in 1848, The Races of Men, and their Geographical Distribution, being volume ix of the Exploring Expedition. In 1854, he had ready for the press The Geographical Distribution of Animals and Plants, being volume xv of the United States Exploring Expedition; but, through the withholding of government appropriations, only the first portion of this valuable Report has been published. Another large work, entitled Man's Record of his own Existence, was only recently completed, and is now passing through the press.

Dr. Pickering was untiring and most conscientious in scientific research, and of great and varied learning. His works are repositories of carefully observed facts on the subjects he had laboriously investigated, along with the conclusions to which he had been led.

With all his learning, he had neither a desire, nor a gift, for display. He was a man of the finest moral sensibilities, and the most perfect integrity, engaged during a long life in absorbing studies, yet asking neither fame nor money, nor any other reward than the privilege of gaining knowledge and storing it up in convenient forms for the service of others. He loved his friends, and was a most genial traveling companion, though naturally reserved among those with whom he was not familiar.

Dr. Pickering was married, in 1851, to Sarah S., daughter of the late Daniel Hammond, Esq., of Boston, and leaves no children. His memory will always be dear to those who knew him; his works should secure for his name a high place in the annals of American Science. J. D. D.

APPENDIX.

Art. LIX.—*Notice of New Fossil Reptiles*; by Professor O. C. Marsh.

The United States Survey of the Fortieth Parallel, in charge of Mr. Clarence King, has made known the fact that a well marked Permian horizon can be distinguished in the Rocky Mountain region; and deposits considered of this age are represented on the geological maps of that survey. This adds much interest to the vertebrate fauna known from near this horizon, and probably belonging to it, as hitherto no Permian vertebrates have been identified in this country, although not uncommon in Europe.

The Museum of Yale College contains an extensive series of Reptilian remains belonging to a peculiar lacustrine fauna, which includes also Amphibians and Fishes. These fossils are from several localities in the West, but mainly from New Mexico, and the geological horizon appears to be in the upper portion of the Permian. These Reptilian remains are in excellent preservation, and among them are several genera, having the more important characters of the *Rhynchocephala*, of which the genus *Hatteria*, of New Zealand, is the living type. The principal points of agreement are the separate premaxillaries; the immovable quadrate; and the biconcave vertebræ. Another character of much interest is the presence of certain hypaxial elements of the vertebræ, first observed by Von Meyer in the Triassic genus *Sphenosaurus*, and called by him intercentral bones, ("*Zwichenwirbelbein*"). These wedge-shaped bones are apparently the homologues of the cervical hypapophyses in the *Mosasauria*, and of the sub-caudal attachments in the *Odontornithes*, and a few recent birds. These intercentral ossifications apparently exist in all the Reptilia yet found in this new fauna, and hence serve to distinguish it. With this character is another of hardly less interest. The anterior rib-bearing vertebræ preserved have three separate articular facets for the ribs; one on the anterior part of the centrum for the head, and a double one above for the bifid tubercle. In the implantation of the teeth and their successional development, these Reptiles resemble the Mosasuria.

These characters, with others mentioned below, indicate two distinct families, which may be called *Nothodontidæ* and *Sphenacodontidæ*, from the typical genera here described.

Nothodon lentus, gen. et sp. nov.

This genus of Reptiles may readily be distinguished by the dentition. In each separate premaxillary there are two slender pointed teeth. In front of the maxillary there are one or two similar teeth, followed by a number with narrow transverse crowns, resembling in form the premolars of some carnivorous mammals. These crowns, when unworn, have a central cusp, and on each side a tubercle, somewhat like that on the premolars of the genus *Canis*. In the present species the first and last of the transverse teeth are smaller than the middle ones. The limbs were short, the long bones had their extremities covered with cartilage, but the carpals and tarsals were well ossified. The centra were very deeply concave, and the tail was long.

The following measurements are taken from the type specimen of this species:

Length of maxillary bone	65·mm
Space occupied by ten maxillary teeth	55·
Height of crown of second maxillary tooth	14·
Height of crown of third maxillary tooth	9·
Antero-posterior diameter	3·
Transverse diameter	8·
Antero-posterior diameter of eighth tooth	5·
Transverse diameter	15·

The present species was about five or six feet in length, and herbivorous in habit. It was apparently slow in movement, and probably more or less aquatic. The remains at present known are from New Mexico.

Sphenacodon ferox, gen. et sp. nov.

In the present genus the anterior teeth are somewhat like those of the reptile described above, but the posterior, or more characteristic ones, are totally different. The crowns are much compressed, and have very sharp cutting edges, without crenulations. In the present species the carnivorous teeth are crowded together, and the crowns placed slightly oblique, and twisted. The jaws were comparatively short and massive. The rami of the lower jaws were apparently united by cartilage only, and the symphysis was short. The vertebræ are deeply biconcave.

Measurements from the type of this species are as follows:

Length of dentary bone	150·mm
Space occupied by teeth	130·
Extent of four anterior caniniform teeth	25·
Extent of twenty compressed teeth	105·

Height above jaw of second lower tooth	15·mm
Depth of dentary bone at symphysis	26·
Height of crown of compressed tooth	8·
Transverse diameter	4·

This reptile was about six feet in length, and carnivorous in habit. Its remains are from the same locality in New Mexico that yielded those of *Nothodon.*

Ophiacodon mirus, gen. et sp. nov.

A third genus of Reptiles allied to the last described is indicated by various well preserved remains from the same locality. The teeth are all carnivorous in type, conical in form, and all are similar. Those in the anterior part of the jaws are recurved, and in general shape resemble those of Serpents. The rami of the lower jaws were united only by cartilage. The vertebræ are very deeply biconcave, and even perforate, and the intra-central bones large. In the present species the teeth are nearly smooth, and somewhat compressed.

The following measurements indicate the size of this reptile:

Extent of anterior sixteen teeth in dentary	75·mm
Extent of anterior five lower teeth	20·
Height of crown of fourth lower tooth	10·
Depth of lower jaw at symphysis	15·
Extent of seven anterior maxillary teeth	33·
Height of crown of first maxillary tooth	9·
Antero-posterior diameter of crown	3·

This species was about as large as those described above, and is from the same geological horizon in New Mexico.

Ophiacodon grandis, sp. nov.

A second larger species of apparently the same genus is represented by portions of the jaws, and teeth, and various parts of the skeleton. In this species the dentary bone is angular at its anterior extremity, and triangular in section. Its external surface is rugose, as in the Crocodiles. The crowns of the teeth are striate at the base, and the latter is furrowed vertically. The teeth are not so thickly set as in the smaller species, and the bases of the crowns are somewhat transverse.

Measurements.

Space occupied by ten anterior lower teeth	140·mm
Depth of lower jaw at symphysis	129·
Antero-posterior extent of symphysis	25·
Depth of dentary bone below seventh tooth	30·
Width of dentary at this point	20·

The present species was about ten feet in length, and the largest reptile yet found in this fauna. The remains are from New Mexico.

Yale College, New Haven, April, 1878.